# PROCEEDINGS

OF THE

# ROYAL SOCIETY OF EDINBURGH.

VOL. IX. 1876–77. No. 96.


## Ninety-Fourth Session.

*Monday, 27th November* 1876.

Sir WILLIAM THOMSON, President, in the Chair.

The following Council were elected:—

*President.*

Sir WILLIAM THOMSON, Knt., LL.D.

*Honorary Vice-Presidents, having passed the Chair.*

His Grace the DUKE of ARGYLL.

Sir ROBERT CHRISTISON, Bart., M.D.

*Vice-Presidents.*

Professor Kelland.
Rev. W. Lindsay Alexander, D.D.
David Stevenson, Esq., C.E.
The Hon Lord Neaves.
The Right Rev. Bishop Cotterill.
Principal Sir Alex. Grant, Bart.

*General Secretary*—Dr John Hutton Balfour.

*Secretaries to Ordinary Meetings.*

Professor Tait.
Professor Turner.

*Treasurer*—David Smith, Esq.

*Curator of Library and Museum*—Dr Maclagan.

*Councillors.*

Dr Andrew Fleming.
Dr Charles Morehead.
Alexander Buchan, M.A.
Robert Wyld, LL.D.
Dr Ramsay H. Traquair.
Dr Thomas Harvey.
Dr John G. M'Kendrick.
Dr J. Matthews Duncan.
Sir T. C. Wyville Thomson.
D. Milne Home, LL.D.
Professor Crum Brown.
James Bryce, LL.D.

*Monday, 4th December* 1876.

The Rev. W. LINDSAY ALEXANDER, D.D., one of the Vice-Presidents, at the request of the Council, gave the following Opening Address:—

GENTLEMEN,—The Council having appointed me to deliver the address at the opening of this the ninety-fourth session of the Royal Society of Edinburgh, I have not felt myself at liberty to decline the appointment, though deeply conscious of my inability to discharge adequately the duty which has thus been laid upon me.

I have, in the first instance, to advert to the changes which have taken place in the fellowship of the Society in the course of the past year. During that period the Society has lost by death *nine* of its Ordinary Fellows and *three* of its Foreign Honorary Fellows. These are by name—

Thomas Login, Esq., C.E., India.
Sir George Harvey, Kt., P.R.S.A.
James Warburton Begbie, M.D., F.R.C.P.E.
Lewis D. B. Gordon, Esq., C.E.
David Bryce, Esq., Architect.
George Stirling Home-Drummond of Blair-Drummond, Esq.
Alexander Russel, Esq.
Thomas Laycock, M.D., F.R.C.P.E.
The Most Noble the Marquis of Tweeddale, K.T., G.C.B., &c.
Adolphe Pictet, Geneva.
Adolphe Theodore Brongniart, Paris.
Christian Gottfried Ehrenberg, Berlin.

Fifteen new members were elected during the past year.

The total number of Fellows of the Society at this date is 419, viz.—

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| Ordinary Fellows, . . . . | 363 |
| Honorary Fellows, . . . . | 55 |
| Non-resident Fellow under the old law, | 1 |
| | 419 |

Following a practice which has grown to be a usage and a rule, I proceed to lay before the Society brief biographical sketches of the deceased members, so far as I have been enabled to gather materials for this purpose. I shall take them in the order in which they have been enumerated above.

Thomas Login,* born at Stromness, in Orkney, in 1823, studied engineering at Dundee. In 1844 he obtained an appointment in the Public Works Department in India, and was engaged from 1847 to 1854 in the construction of the Ganges Canal under the late Sir P. T. Cautley, who has most cordially acknowledged that to Mr Login's advice and assistance "he was greatly indebted in designing and executing that work."

After this period Mr Login was invalided and came to England. In 1857 he returned to India, where he acted successively as executive engineer of the Darjeeling and Roorkee Roads and of the Northern Division of the Ganges Canal. In 1868 he again came to England, returning to India in 1870 to occupy the post of officiating superintending engineer at Umballa, where his labours were varied and arduous, and a return of his illness cut short his useful career on 5th June 1874, while engaged in an inspection of the Thibet Road in the Punjaub.

While resident in India Mr Login made several communications on engineering, among which may be mentioned his paper on the "Benefits of irrigation in India, and on the proper construction of irrigating canals," for which he received a Telford Premium from the Institution of Civil Engineers; his "Description of the Ganges Canal," and recommendations for "Roads, Railways, and Canals for India;" and his paper "On the Delta of the Irrawaddy," communicated to this Society in 1857.

Mr Login was a member of the Institution of Civil Engineers, and was elected a Fellow of this Society in 1857.

George Harvey was a native of St Ninians, near Stirling, where he was born February 1806. His father, a respectable tradesman in that city, and a man of intelligence and piety, trained up his children in the fear of God, and in a strict regard to the claims of

* This sketch has been furnished by David Stevenson, Esq., C.E.

honour and duty, and sent them forth to the business of life well educated and thoroughly imbued with upright and virtuous principles. From an early period George showed that his bent was towards the pictorial art; and his boyish efforts in that direction proved that he had the natural gifts which, under due cultivation, promised to lead to eminence. In order to obtain this necessary culture he came in 1823 to Edinburgh, where he studied at the drawing school connected with the Institution. His first pictures were exhibited in 1826, and attracted much attention. In his earlier efforts he seems to have had Wilkie before him as his model; at any rate, his subjects were selected from scenes of humble Scottish life, such as Wilkie delighted to delineate. These Harvey reproduced with scrupulous truthfulness, and his pictures show a keener sense of the more humorous side of his subject even than those of Wilkie. The scenes he preferred to delineate were such as he had himself witnessed, and the features of which remained vividly impressed on his memory. One of his earliest pictures represented a village school during school hours,—the respectable master engaged in hearing a lesson from a class of boys and girls, and the rest of the pupils employed either in working at their slates or conning their lessons, or in weary vacuity waiting for the season of dismissal, or, as their bent inclined, playing tricks and working mischief out of the master's sight. This picture attracted the attention of an eminent patron of art, who desired to purchase it; but Harvey, having promised it to a friend, would not consent to sell it, even though his friend urged him not to lose the advantage, so important to a beginner, of getting his picture placed in the gallery of a celebrated collector. To the village school Harvey resorted oftener than once, even in the more advanced stages of his career, for the subject of a picture, as his well-known pictures of "The Examination" and "The Skule Skailin'" show. Other scenes of ordinary Scottish life were depicted by him at this time, such as "The Leisure Hour," "Disputing the Billet," "The Small-Debt Court," and in later years his "Curlers," his "Highland Funeral," his "Penny Bank," show the undying interest which the habits, pursuits, and manners of his countrymen had for him. As a religious man, the religious history of his country could not fail powerfully to engage his regards, and in

connection with this some of the noblest efforts of his pencil were produced; his Covenanter pictures—The Preaching, Baptism, and Communion, as well as "The Battle of Drumclog"—attesting how deep was his sympathy with those who in evil days had to seek their spiritual sustenance and contend for their spiritual liberty at the peril of their lives; while his "Reading of the Bible in Old St Paul's," his "Bunyan in Prison," and his "Bunyan selling laces on Bedford Bridge," show that it was not to the religious history of his own country, or the struggles and sufferings of his own countrymen, that his sympathies were restricted. In the ecclesiastical movements of his own time, also, he took a deep interest; and his "Quitting of the Manse" remains to show how he could appreciate a noble sacrifice for conscience' sake on the part of those with whom he himself had no ecclesiastical connection. In the wider field of general historical painting Harvey did not attempt the delineation of great and stirring events, but contented himself with depicting scenes and actions of individual life or personal enterprise. As among his most powerful efforts in this wider field of his art may be mentioned his "Dawn revealing the New World to Columbus," his "Shakespeare before Sir Thomas Lucy," his "Robbers melting Plate," his "Castaway," and his "Dr Guthrie Preaching in the Highlands." He was fond also of painting groups of children, whose ways he had carefully observed, into whose affections and sympathies he lovingly entered, and from whose mimic sports he could draw lessons which by his pencil he sought to impress on older folks. It is only necessary to name his "Children blowing Bubbles in Greyfriars' Churchyard," and his "Wise and Foolish Builders," to illustrate his success in this department of his art. In his later years he betook himself to the painting of landscapes; and here, in the judgment of those most qualified to judge, he was at his best. As a delineator of Scottish pastoral scenery, whether in the Lowlands or in the Highlands, he in many respects stands without a rival. In portrait-painting he was less successful; still some noble portraits, that, for instance, of the late Professor Wilson, came from his easel; and in several of his historical pictures characteristic likenesses of eminent men living at the time are introduced.

I cannot pretend to offer a critical estimate of Harvey's merits

as an artist. Even an unskilled observer, however, could not fail to be struck with the more prominent qualities of his works,—the truthfulness of representation, the clearness of conception, the power and precision of execution, and the freshness and thoughtfulness by which his pictures are characterised. A peculiar excellence attaching to the productions of his pencil is derived from their high moral character. Of his historical paintings each depicts some scene of deep moral interest, or illustrates and enforces some great moral or religious lesson; and when he ceased to occupy himself with such subjects, it was to Nature in her serener and grander aspects that he turned, or among the dwellers in quiet pastoral regions that he sought the objects of his art. In scenes of calm natural beauty, amidst the solemn silence of the everlasting hills, he delighted to roam, and such scenes he sought especially to transfer to his canvas. They lifted up his own soul to God, and he sought by his art to make them the means of producing the same effect on others. He delighted also to depict scenes in the common life of men, scenes which had powerfully touched that chord of human sympathy which so strongly vibrated in his own soul. With a deep sense of humour, and with an eye for the ludicrous both in form and action, he never stooped to cater for the mere amusement of the public, nor did he ever use his skill in such a way as to offend the sensibilities of the least refined. Nothing mean, nothing trivial, nothing fantastic, engaged his pencil. In all he did a high moral purpose is discernible, and his works, if they have secured for him the reputation of a great artist, no less commend him as a great moral teacher. This is wholly in keeping with his general character. Endowed with genius and keen susceptibilities, he was at the same time a man of high principle, of a vigorous and manly intellect, of simple and natural tastes, of broad sympathies, of warm affections, and of a kindly and genial spirit.

Not long after exhibiting his first pictures Harvey became an Associate of the Academy. From that time forward he took a lively interest in that Institution, and to his zeal and energy it was in no small measure indebted for its establishment and early success. In 1870 he appeared as its historian in a volume in which the origin and progress of the Academy are narrated, and many

interesting documents connected with its history are given; the volume is entitled "Notes on the Early History of the Royal Scottish Academy." In due time he became an Academician and a member of Council, and on the death of the late Sir John Watson Gordon he succeeded him as President of the Academy. Some time afterwards he received the honour of knighthood from the Queen.

Endowed with a constitution robust and sound, Sir George Harvey was able up to an advanced period of life to pursue without serious interruption the work of his profession. As he approached his seventieth year, however, his health began to give way, and symptoms of a serious kind soon showed themselves. In the spring of 1874 his illness assumed so serious a form that his life was despaired of; and though he rallied so far as to be able to leave his room, take short drives, and receive his more intimate friends, it became increasingly manifest that his work was done, and that his earthly career must soon reach its close. Calmly, serenely, surrounded by loving friends, and tended with affectionate solicitude by those nearest and dearest to him, he for several months awaited his end. This came to him on the evening of the 22d of January 1876, when he peacefully breathed his last.

Sir George Harvey became a Fellow of this Society in 1867.

James Warburton Begbie was born at Edinburgh on the 19th of November 1826. He was the second son of Dr James Begbie, for many years well known and held in much repute as a consulting physician in this city. Destined to follow his father's profession, young Begbie was carefully educated with that view. His professional studies were prosecuted at the University and the Surgeons' Hall, Edinburgh, and afterwards at several of the continental schools, including those of Paris, Vienna, and Italy; and he had all along, while pursuing his studies, the advantage of his father's constant superintendence, instruction, and counsel. His degree of M.D. was taken in 1847, and in 1852 he was elected a Fellow of the Royal College of Physicians. In 1855 he was appointed a physician and clinical lecturer in the Royal Infirmary; and much about the same time he began to lecture on the practice of physic in the Extra-Academical School. His period of service at the Infir-

mary expired in 1865, and at this time he gave up lecturing, as his private practice had so increased that he could no longer give the time required for this. For the same reason he was obliged to resign the office of Examiner in Medicine for the Edinburgh University, to which he had been appointed in 1869. On relinquishing his connection with the Infirmary he devoted himself to private practice as a physician; but after the death of his father, which took place in 1870, he found it necessary to retire from ordinary practice and devote himself to the work of a consulting physician. In this capacity he continued to labour till the close of his life; and in it he attained a position which has been described as almost unique in his profession, his consulting room, on days when he was to be seen at home, being crowded with patients of all classes, and his services being in request, not only in all parts of Scotland, but frequently also in England. For this he was indebted, in some degree, to the urbanity and kindliness of his manner, in a greater degree to the excellent footing on which he stood with members of his own profession, but most of all to his undoubted skill, knowledge, and experience as a physician.

In the midst of his professional engagements, Dr Warburton Begbie found time to furnish several valuable contributions to the literature and science of his profession. These appeared, for the most part, in the pages of the "Edinburgh Medical Journal," to which he was for many years a frequent contributor. He published also, at an early stage in his career, a little work, entitled "Handy Book of Medical Information and Advice. By a Physician." This, though published anonymously, speedily obtained an extensive circulation, which was much increased when the authorship of the work became generally known. In the literature of his profession he was deeply versed, and his extensive knowledge of the history of medicine enabled him to illustrate his own writings by appropriate citations from his predecessors in the same field of inquiry and observation. To his other accomplishments he added that of being an excellent linguist; with the classical writers of Greece and Rome he was familiar, and he was able to converse freely in several of the modern European tongues. As a lecturer on medicine he was distinguished by the accuracy and fulness of his knowledge, by the perspicuity of his style, and by the minuteness with

which he entered into the exposition of his subject, both in its theoretical aspects and in its practical details; and the same features are discernible in the published productions of his pen. When the British Medical Association met in Edinburgh in the autumn of 1875 Dr Begbie was selected to act as orator of a section of that body, and on that occasion he delivered an address on the practice of medicine in ancient and modern times, which displayed all the excellent qualities of his manner as a lecturer and a writer, and was not only well received by his professional brethren, but welcomed with hearty applause by the general public.

The incessant demands made upon him in the exercise of his profession, and his unsparing devotion to the case of all who sought his aid, his innumerable and often exhausting journeys, and the toil, physical and mental, which he endured, began to tell upon a constitution originally sound and healthy but not remarkably robust. For some years before his death he had, at intervals, suffered from weakness in the action of the heart; and these attacks had come to be so frequent that he found it necessary, in the beginning of the present year, to seek relief by retiring for a season from the active duties of his profession. With this view he left Edinburgh in the beginning of February last, intending to proceed by easy stages to the south of England and ultimately to Italy. He had not, however, reached farther than to Carlisle, when the symptoms of his illness showed themselves in so aggravated a form that he saw his case had become one of imminent danger. He accordingly returned home. Here, at first, he seemed to rally, but after a few days his strength gradually sank, and though several of the most eminent of the medical practitioners in the city were in constant attendance upon him, it soon became evident that a fatal issue could not be averted. He died on Friday the 26th of February 1876. His funeral took place on the following Thursday, and was attended by some of the most distinguished members of the legal and medical professions, and by a large company of the citizens.

Dr Warburton Begbie had all the qualifications of a great physician. To natural abilities and excellent general culture he added profound knowledge of his profession, extensive experience in the practice of it, great skill in the discernment of disease, and a happy facility in suggesting fitting methods of treatment. His high moral

character also, and the known conscientiousness with which he devoted himself to the case of those who consulted him, tended to inspire confidence in him on the part of the public, as well as to encourage his professional brethren to appeal to his advice in cases of emergency; nor were there wanting that "*hilaris vultus*," that kindly demeanour, and that gentle manner, which Celsus tells us are such excellent qualities in the "peritus medicus."* Pleasant looks and cheerful words will not of themselves, it is true, effect a cure; but every experienced physician knows how materially they are helpful to the end he seeks to gain with his patient:—

> "Sunt verba et voces quibus hunc lenire dolorum
> Possis, et magnam morbi depellere partem."†

Few men have passed away more sincerely lamented than was Dr Warburton Begbie, as well by his professional brethren as by the general public. As a skilled physician, as a man of varied culture, high moral character and amiable manners, as a sincere Christian and a generous benefactor to the poor, he has left behind him a reputation which will not soon be obliterated.

Dr Begbie became a Fellow of this Society in 1870.

Lewis D. B. Gordon,‡ son of Joseph Gordon, writer to the Signet, was born at Edinburgh in 1815, and received his early education at the High School and University of Edinburgh.

Having determined to follow the profession of engineering, young Gordon was first sent to Dundee, where he had the benefit of working at the bench and studying engine-fitting at the Dundee Foundry. His next introduction to practical work was at the Thames Tunnel, where, by the kindness of Mr Brunel, he had an opportunity of seeing all the details of that unique work. Finally, he completed his studies at the Royal Mining Academy, Fribourg, and the Ecole Polytechnique at Paris.

* Periti medici est non protinus ut venit apprehendere manu brachium, sed primum residere hilari vultu, percunctarique quemadmodum se habeat, et si quis ejus metus est eum probabili sermone lenire.—Cels. *De Re Medica*, b. iii. c. 6.

† Hor. Epist. I. 1. 35.

‡ This sketch has been contributed by D. Stevenson, Esq., C.E.

On his return to Scotland he commenced practice as a civil engineer in Glasgow, in partnership with Mr Lawrence Hill.

In 1840 the Government determined to establish a professorship of civil engineering in the University of Glasgow, for which Gordon became a candidate, and so high were his recommendations that he received the appointment. There can be no doubt that at so young an age, and with the strict sense of duty which ever animated him, Gordon felt the task of organising the new chair to be one that called forth all his energies. No man could be more fully alive to the importance of his new office, or knew better the large amount of knowledge—scientific and practical—that was required of its occupant, and his sensitive mind felt the responsibility he had undertaken very keenly. But he had a spirit that was not easily daunted by difficulties, and in anticipation of his appointed work he produced the syllabus of a course of study, embracing a very wide field of engineering, under the following general heads:—

The Mechanical Effect produced by Forces, and its Measure.
Physical and Mechanical Properties of Materials.
Results of Experiments on the Resistance of Materials.
Friction.
Doctrine of Mechanics.
Animal-power and its Recipient Machines.
Water-power and its Recipient Machines.
Steam-power and the Steam-engine.

After delivering his lectures he had the satisfaction to find that he had got through the first session with comfort to himself and profit to his pupils.

It may here be noticed that the skeleton syllabus of his opening course of lectures was afterwards, in more matured form, published in 1847, under the unassuming title of "Engineering Aphorisms and Memoranda," and ultimately, in 1849, with further additions, it was published, under the title of "A Synopsis of Lectures on Civil Engineering and Mechanics."

He, however, knew that he had to *make* his professional character as an engineer, and that this was not possible were all his energies to be given to his professorial duties, and therefore, during the time he occupied the chair, he invariably, when the session was completed, devoted his whole time to the practice of his profession

as an engineer,—first in conjunction with Mr Lawrence Hill, and latterly with Messrs Liddell and Newall, with whom he entered into a second copartnery.

He ultimately found, as his engineering business increased, that he could not fulfil the duties of his chair to his own satisfation, and, in 1855, he resigned his professorship, in which he was succeeded by the late Professor Rankine.

During the time of his first partnership he, in conjunction with Mr Hill, was employed in general engineering business in Scotland, and reference may, in particular, be made to the investigation for the water supply of Glasgow in 1845, when they came to the conclusion "that the nearest adequate supply of pure water, that can be brought to Glasgow by gravitation, is what is afforded by the overflow of Loch Katrine." This project was revived in 1852 by Professor Rankine and Mr John Thomson, and was ultimately, as is well known, successfully carried out by Mr J. F. Bateman. Among other works, Messrs Gordon and Hill were employed in advising the Marquis of Breadalbane in his mining operations at Tyndrum, and in constructing the great chimney for Messrs Tennants' works at St Rollox, which was, at that early period, considered to be a work as bold as it was successful.

But it was in connection with Messrs Liddell and Newall that most of Gordon's engineering work was done. Liddell and Gordon were engineers for several railways in England and Wales, and designed and executed many iron bridges, among which may be mentioned the Hereford, the Usk, and especially the Crumlin Viaduct in South Wales, consisting of 10 spans of 150 feet,—a structure of marvellous lightness, and withal of requisite strength and rigidity. Their firm was rendered famous by the introduction of wire ropes, which Gordon had seen in use at the mines in Germany, and introduced into England in 1840, under a patent taken out by Gordon, Newall, and Liddell. The uses of these ropes became highly important when they were ultimately so largely employed in protecting the electric wires for submarine cables,—a new and large field of work was thus opened up for the firm, which was designated R. S Newall and Co. of Gateshead. The firm manufactured and laid upwards of 4500 miles of cable in different parts of the world. It was on one of his numerous voyages in connection with marine telegraphs that

he, in 1859, had the misfortune to be shipwrecked in the Red Sea, when he suffered exposure on a barren rock for four days, and contracted illness from which he never recovered. Latterly he suffered from paralysis, which for many years prevented his engaging in active business.

In preparing his lectures for the Glasgow professorship, Gordon felt that at his early age he had much knowledge to acquire, and he seems to have had no difficulty in giving the result of his investigations to the Glasgow Philosophical Society, of which he was a member, and to which he communicated, between 1840 and 1844, many papers.

In 1841, in a paper "On the Determination of the Melting Points of Metals," he gave an account of the experiments of Plattner of Fribourg. In the same year, under the title of "Dynamometrical Apparatus," he detailed the investigations of M. Morin of Metz, and, under the "Temperature of the Earth," he gave an elaborate account of the thermometric observations of Forbes and Herr Dove. He also made communications on "The Flow of Water through Pipes," the "Measure of Impact by Pressure or Weight," and other subjects of interest to the Society.

Of papers and pamphlets, on subjects of general engineering, the following imperfect list may be given:—

"Description of the Great Chimney of St Rollox at Glasgow." 1844.

"On the Supply of the city of Glasgow with Water from Loch Katrine." 1845.

"Railway Economy,—an Exposition of the advantages of Locomotion by Locomotive Carriages instead of the present system of Steam-tugs." 1849.

"Railway Economy,—Use of Counter-pressure Steam in the Locomotive Engine as a Brake. Translated from M. L. Le Chatelier, Ingenieur en Chef des Mines." 1869.

"Exposition of a Plan for a Metropolitan Water Supply."

"On the most Advantageous Use of Steam." 1845.

"Short Description of the Plans of Captain J. Vetch, R.E., for the Sewerage of the Metropolis." 1851.

In 1848 he translated from the German the "Principles of the Mechanics of Machinery and Engineering," by J. Weisbach, of

the Royal Mining Academy, Fribourg; and as a supplement added some original appendices "On the Strength of Materials," "Tubular Bridges," and the "Rigidity of Cordage."

Even after being laid aside from active business he continued to take a lively interest in engineering, and never failed to answer, in carefully considered letters, whatever his friends in the profession submitted for his friendly advice, which was always promptly and ungrudgingly given.

In proof of what I may call the *disinterested interest* he took in his profession and his professional brethren, it is pleasant to know that the latest work in which Gordon was engaged was a labour of love and regard for the memory of a professional brother.

About the close of 1875 it occurred to Mr James R. Napier of Glasgow and Gordon, that a memoir of the late Professor Rankine, and a republication of his contributions on scientific subjects to Societies and journals would be a task agreeable to his friends, useful to his former pupils, and acceptable to men of science. His last letter to Mr Napier on the subject is dated 24th February 1876, just two months before his death. But his correspondence, which had been going on three months, then ceased, and his friendly desire—so like his nature—to give his time and strength as one of the editors of the works of his successor in the chair of engineering at Glasgow came to an end. He died at Poynters Grove, near London, on the 28th April 1876. He became a Fellow of the Society in 1845.

Resignation to the will of God was the ruling principle of the last years of Gordon's long illness, and this gave cheerfulness to his daily intercourse, which was the admiration, and indeed the envy, of the many friends who now lament his death.

David Bryce was a native of Edinburgh, where he was born in 1803, and where he received his early education, principally at the High School. The son of an architect he determined to follow his father's profession, for which from an early age he had shown special aptitude. After serving an apprenticeship in his father's office, where he laid the foundation of his future eminence as a designer, and acquired that technical skill by which he was distinguished, he while yet young became assistant to Mr Burn, a well-known archi-

tect, by whom he was soon after received into partnership. On Mr Burn's removal to London in 1844, Mr Bryce commenced business for himself, and soon earned a high reputation in his profession. For a short time he was in partnership with Mr Robert Anderson, and a few years before his death he was joined by his nephew, Mr John Bryce, in conjunction with whom he carried on business to the close of his life.

During his lengthened career Mr Bryce executed many important works, which remain to attest his ability and skill. In style he was cosmopolitan, and, accordingly, the buildings he designed are in various styles of architecture. In Edinburgh the Life Assurance Company's Office, the Scottish Widows' Fund Office (originally the Western Bank), the Subscription Library, the Surgical Hospital, the Standard Assurance Office, the Sheriff Courts, the Union Bank and Free St George's Church are in the Italian style, as are also the Western Bank and the Scottish Widows' Fund Office in Glasgow; the British Linen Company's Bank and the Clydesdale Bank, in Edinburgh, are in the Palladian manner; and the Fettes College, Edinburgh, and the Dundee Exchange, are in French Gothic. For churches he generally adopted the Gothic, rarely the Norman, and still more rarely the Italian. For a few public buildings he employed the old Scottish style, as in the New Royal Infirmary, Edinburgh, and the Sheriff Courts, Kirkwall; but he reserved this chiefly for private mansions. Of these he erected and altered a vast number throughout the country; indeed, it has been affirmed on good authority, that "perhaps no man in the kingdom has altered more mansion-houses than Mr Bryce."* Here, it may be said, his chief success was achieved, and here his peculiar genius was chiefly manifested. "Many an inconvenient, comfortless dwelling has been by him converted into one of the most comfortable residences, and many a tame, uninteresting, commonplace mansion rendered a picturesque feature in the landscape."† Of the houses of which he was the architect the most noteworthy are Cortachy House, the seat of the Earl of Airlie; Glen House, the property of Mr C. Tennent; Ballinkinrain House, the property of Mr Orr-Ewing, M.P.; Hartrig House, near Jedburgh, the residence of Lord Campbell; Castlemilk, near Lockerbie, the property of Mr

* "The Builder," for May 27, 1876, p. 507. † Ibid.

Robert Jardine; Kimmerghame, the residence of Mr Campbell Swinton; Broadstone, the residence of Mr J. Birkmyre; and Woodcroft, the residence of Colonel Davidson. All these are in the old baronial style. In other styles are Panmure House (Elizabethan); Langton, near Dunse, the seat of Lady Elizabeth Pringle (Elizabethan); Portmore, the residence of Mr Mackenzie (Elizabethan); Kinnaird Castle (French); Belladrum, the property of Mr Merry, M.P. (French); Eastburgh, the residence of Mr Carnegy (French); and Kincaid Castle, the seat of the Earl of Southesk. In adopting these different styles Mr Bryce was not a mere copyist; he impressed upon all his work the stamp of his own taste and genius. Essentially an artist, he had a fine perception of harmony, and he sought always to bring his buildings into fitness for the place they had to occupy, and into harmony with the surrounding scenery, so as to make them part of one great picture. "When he had a work on hand where anything like scope was allowed to his powers, he wrought upon it as a painter does upon his easel, recurring to it again and again, altering proportions and rearranging the grouping of masses, and in doing this he did not hesitate occasionally to obliterate what had cost him much labour."*

Mr Bryce stood high in his profession, and his name will remain, along with those of Adam, Hamilton, and Playfair, among those of the greatest of modern architects. He was Grand Architect for Scotland, a Fellow of the Royal Institute of British Architects, and a member of the Royal Scottish Academy, as well as a Fellow of this Society. He was a man of varied acquirements, of high integrity, and of a genial disposition. Under a blunt manner, and somewhat rough exterior, there lay in him a kindly nature and a generous heart; and, whilst his society was much sought after by his friends, he drew to him the esteem alike of his servants and his employers.

He died on the 7th of May last, in his seventy-fourth year. He became a Fellow of the Royal Society in 1856.

George Stirling Home-Drummond was the eldest son of the late Henry Home-Drummond, Esq. of Blair-Drummond, and great-grandson of the celebrated Henry Home Lord Kames. His father was for many years member of Parliament, first, before the passing

* "The Builder," as above.

of the Reform Bill, for Stirlingshire, subsequently for Perthshire; in which capacity he rendered important services, particularly by the laws which he procured to be enacted, of which the Act for the Regulation of Public Houses in Scotland, and that for the Small Debts Jurisdiction in the Sheriff Courts, may be mentioned as specially valuable. He died in 1867, and was then succeeded in his estates by his son, the subject of this notice. This gentleman was born in Edinburgh on the 1st of March 1813. He received his university education at Oxford, where he was entered at Christ Church College. Some time after leaving the university, he travelled through Palestine and other parts of the East. Of this tour he wrote an account, which was printed for private circulation, but never published.

Mr Home-Drummond was a man of extensive culture and varied pursuits. With the languages and literature of ancient Greece and Rome he was familiar; of several of the languages of modern Europe he was accurately master, especially French and Italian, which he wrote and spoke with ease and fluency; and in several branches of natural science, he was proficient. He was chiefly interested in antiquarian research, and became especially skilled in the deciphering of ancient documents. One of the fruits of his labours in this field was the collection of a mass of notes and papers relative to the Earldom of Monteith, which, it is understood, is now in the possession of a learned legal antiquary, with the view of being used in the preparation of a historical volume.

Though interested in literary and scientific pursuits, Mr Home-Drummond did not neglect the duties of a large landholder and country gentleman. In this capacity as well as in the relations of private life, he was much respected and esteemed. He died somewhat suddenly in London, on the 3d of June in the present year. He was elected a Fellow of this Society in 1869. He was also a Fellow of the Society of Scottish Antiquaries and a Fellow of the Geological Society.

Alexander Russel was a native of Edinburgh, where he was born on the 10th of December 1814. His father was a solicitor practising in that city, and his mother, from whom it is said he derived much of his mental vigour and character, was the daughter

of a Mr Somerville, whose interest in politics and stanch adherence to his party may be said also to have been inherited by his descendant. After receiving education at several schools in Edinburgh Mr Russel was apprenticed to the printing trade with Mr John Johnstone, a gentleman well known in connection with literature as an editor and author still more than as a printer. To young Russel the acquaintance and society of this gentleman and his gifted and accomplished wife were of great advantage. They soon discovered his abilities, and they did much to foster his taste for literature as well as to direct his studies. By them he was encouraged to the use of his pen in composition, and several of his early essays were introduced by Mrs Johnstone into "Tait's Magazine," of which she was at that time the editor. From the outset, however, his bent was to politics rather than to literature; and having been at an unusually early age appointed editor of the "Berwick Advertiser," he was enabled thenceforward to devote himself to a career to which his tastes inclined him, and for which he was by natural abilities and acquired facilities and resources peculiarly fitted. After some years he exchanged the editorship of the "Advertiser" for that of the "Fife Herald," which post he continued to hold till towards the close of 1844. By this time his reputation as an able writer and skilful editor was established; and in 1845 he, after a connection of short duration with a paper in Kilmarnock, was invited to become the colleague of the late Mr Maclaren as editor of the "Scotsman," then, as it is still, the leading political journal in Scotland. In connection with Mr Maclaren he continued to edit this journal, taking upon him almost the entire management, until 1849, when Mr Maclaren retired, and Mr Russel became sole editor. In this position he remained up to the time of his death, though latterly, through failing health, he was obliged to devolve upon others much of that work which for many years he had with Herculean vigour done alone.

The "Scotsman" newspaper is, as is well known, the recognised principal organ of the Whig party in Scotland; and for the advocacy and diffusion of the principles held by that party it was designed. Of that party Mr Russel was a stanch adherent, of its principles he was the bold, uncompromising, and consistent advocate, and its interests he zealously laboured to advance. The services he ren-

dered to his party were immense. Nor were the members of the party slow to acknowledge this; as was attested in many ways, but especially by the testimonial which was presented to him in 1859, "in recognition of his services and as a mark of respect for his honourable and independent conduct in public and private life," and by his being spontaneously elected a member of the Reform Club in London, which has been described as "the central organisation of the Liberal party." Nor was it by persons of that party alone that his merits were acknowledged, and the tribute of respect to his consistency and integrity rendered. Perhaps no provincial newspaper was so generally read by men of all parties as the "Scotsman" whilst under Mr Russel's management; and however much some of its readers might dissent from his opinions or dislike his principles, there were none who did not admire the boldness, the steadfastness, and the consummate ability with which these were maintained and advocated. For the conduct of a public journal he was eminently qualified as well by the brilliancy of his faculties as by the extent and variety of his knowledge, his sound sense, and the manly vigour which characterised all his utterances on questions of public interest. Of him may it be said, with much greater justice than of the person to whom Addison first addressed the line, that he was

> "For wit, for humour, and for judgment famed."

If sometimes his wit was over keen, if now and then in his humour there was a flavour of coarseness, if occasionally he jested where jesting was "not convenient," if the showers of ridicule with which he assailed the objects of his criticism were often more copious than deserved, there is this to be said on the other side, that his judgment was seldom at fault, that in his satire there was no malevolence, that his antagonism was open and manly, that he scorned to use any base arts of insinuation, vituperation, or slander, and that when he wielded the scourge there was so much cleverness in his manipulation, such felicity of expression and illustration, and withal such a joyous hilarity pervading the whole, that even those who were the objects of his most pungent strictures found it impossible to withhold their admiration, or to resent with bitterness the castigation they had received.

Those who have been born and brought up in towns, and whose avocations restrict them to a residence in "the busy haunts of men," have often little or no relish for natural scenery, and no inclination towards the pursuits or pastimes of country life. Dr Johnson, it is well known, thought Fleet Street much to be preferred to Greenwich Park, and maintained that no man would live in the country who could help it. Boswell, in recording this with approval, "shelters" himself under the authority of one whom he describes as a man of fashion, but distinguished also by a love of literature, who declared that he preferred the smell of a flambeau at the playhouse to the fragrance of a May evening in the country.* Madame de Stael, when an enthusiastic friend was expatiating on the delight which such a heart as hers must take in green fields and gentle streams, replied—"Ah! il n'y a pour moi de ruisseau qui vaille celui de la Rue de Bac," a street in the Faubourg St Germain, through which a paltry rivulet flows. There are many who, without having a distaste for the country so pronounced as this, are yet supremely indifferent to it, and either never care to visit it, or if they are seduced into it, are never happy till they turn their back on it and find themselves once more among streets and houses. Mr Russel was not of this class. Though born in a town, and from his youth up a dweller in towns, he had a passionate love for the country, and found no relief from his toils so refreshing and exhilarating as a ramble among the hills and by the streams of his native land. He was also enthusiastically devoted to angling, and there are few of the angling waters of Scotland with which he was not acquainted. With the Gala and the Tweed he was especially familiar, and often sought on their banks that recreation which their streams afforded to him in the pursuit of his favourite pastime. With the habits of the tenants of the waters he was careful to make himself acquainted, and he knew them all well, from the trout to the salmon. His observations were embodied in an article which appeared in the "Quarterly Review," and which he afterwards expanded into a volume; and on the subject of fishing he became so much of an authority, that he was repeatedly examined before Parliamentary Commissions appointed to inquire into this matter. Besides tra-

* Life of Dr Johnson, i. p. 438, 8vo edit. Lond. 1807.

versing widely his own country, Mr Russel in 1850 made a tour in Ireland; in 1863 he for the first time visited the Continent; and in 1869 he went to Egypt, and was a witness of the ceremony at the opening of the Suez Canal. In 1872, after his first serious illness, he made a lengthened tour through the south of Europe, visiting several places in France, Portugal, Spain, and Northern Italy.

The illness under which Mr Russel suffered was a form of heart disease, and by this he was for some years before his death so seriously affected that he was obliged to retire to a great extent from the literary work of the "Scotsman." Towards the end of last year the attacks became more frequent and severe, and his strong constitution at length sank under them. He died on the 18th of July last.

Mr Russel became a Fellow of the Royal Society in 1870.

Thomas Laycock was born at Witherby, in Yorkshire, on the 10th of August 1812. He was the son of a Wesleyan minister, and received his early education at the Wesleyan Academy, Woodhouse Grove. Destined for the medical profession, he was, when fifteen years of age, apprenticed to Mr Spence, surgeon, of Bedale. He afterwards prosecuted professional studies at University College, London, where he followed the full curriculum; subsequently, he went to Paris, where he studied under Velpeau and Lisfranc; and from this to Göttingen, where he took his M.D degree "summâ cum laude." On his return from the Continent he settled at York as a general medical practitioner. In 1841 he was appointed physician to the York Dispensary; in 1844 he acted as Statistical Secretary to the British Association, which met that year at York; and in 1846 he became Lecturer on the Theory and Practice of Medicine in the York Medical School. On the retirement of the late Professor Alison in 1855, he was elected Professor of the Practice of Medicine and of Clinical Medicine in the University of Edinburgh. In 1869 he was appointed Physician to the Queen in Scotland. He was a Fellow of the Royal College of Physicians as well as of the Royal Society of Edinburgh.

Endowed with great mental ability, and possessed of indomitable energy, Dr Laycock contributed largely to the literature and science of his profession. He was an excellent linguist, and kept himself

abreast of the most important advances in medical science and speculation on the Continent. He translated Prochasta's Treatise on the Nervous System and Unger's Physiology. His own contributions to various branches of medical science were many, and most of great value. Besides numerous papers in the medical journals and in the transactions of learned societies, he published a Treatise on the Nervous Diseases of Women, in which he first developed his views as to the scientific data of unconscious and involuntary brain function, and explained thereby the phenomena of mesmerism, dreaming, and insanity. The views advanced in this work he afterwards extended and completed as a system of Practical Philosophy, in a work in two volumes, entitled "Mind and Brain, or the Correlation of Consciousness and Organisation," of which the first edition appeared in 1860 and the second in 1869. He also devoted much attention to the subject of epidemiology, and his papers on this and on questions of sanitary reform contributed much to turn attention to the important matter of public health, and to direct to the use of measures best fitted to secure and promote it.

The natural bent of Dr Laycock's mind was towards speculation and theory; but he had what many theorists and speculative thinkers have not, a capacity of minute observation and a patience of details which have enabled him to give to his writings a value and importance independent of the theories which they are intended to advocate. As to the soundness of these theories there may be, and I presume are, differences of opinion, but there can be but one opinion as to the conscientious carefulness and exactitude of his observations, and as to the value of the facts which he has collected and described. His doctrine concerning the reflex function of the brain is now, I believe, universally recognised by physiologists, and its importance both in a scientific and a practical relation acknowledged to be great. To the subject of mental disease Dr Laycock devoted much attention; and he did not a little to advance the science of mental pathology, and thereby to place on a firmer basis the theory of the treatment of the insane. As a professor his aim was not merely to communicate knowledge to his students, but still more to awaken them to thought, to stimulate them to inquiry, and to urge them to use their faculties in the independent pursuit of

truth. Complaints have sometimes been made of his want of lucidity as a lecturer, but the fault here may have been rather on the part of the student than on the part of the professor; for where the mind has not been previously trained to processes of thinking, the most lucid exposition of doctrines which are speculative and abstract will fail of conveying to the hearer a clear and just conception of the teacher's meaning. Dr Laycock's lectures were always thoughtful and instructive, and if they often required an effort of close attention and thought on the part of the student to apprehend them, this was never rendered without great advantage to the student thence accruing.

In outward manner Dr Laycock was somewhat cold and formal, and there was in his addresss what had the appearance, though slight, of hauteur. But under all this there lay an extreme kindliness of disposition, which manifested itself in many acts of generous beneficence and tender sympathy.

For some years before his death Dr Laycock's health had begun to fail. In 1857 he had been visited with a threatening of phthisis; and though he seemed entirely to recover from this, the insidious malady continued lurking in his system. In 1866 disease of the left knee-joint rendered amputation of that limb necessary; and this gave a shock to his system from which he never wholly recovered. He was able, however, in the enjoyment of an apparently fair measure of health and strength, to continue his ordinary avocations and to fulfil his professorial functions up to the close of last winter session, when an accession of his old malady laid him aside. As the summer advanced pulmonary consumption gradually extended its ravages in his frame, and on the 21st of September he breathed his last.

Dr Laycock became a Fellow of this Society in 1856, the year after his appointment to the Chair in the University.

George Hay, Marquis of Tweeddale, was born at Yester House, on the 1st of February 1787; and succeeded his father as eighth marquis in 1804. In the same year he entered the army, and he was engaged in active service during the whole of the Peninsular War. He served as aid-de-camp to the Duke of Wellington, by whom he was highly esteemed as a brave soldier and an able officer. He afterwards served in Canada. He was wounded at the battle of

Busaco, and he received other wounds in subsequent engagements; and when, in 1814, he returned home invalided, he was so lame from the effects of his wounds that he was obliged to use crutches. As a young man he was remarkable for his great strength, and many stories are told of his powers both on the field and in pugilistic encounters. He wielded a sabre longer by several inches than the regulation standard; he was an excellent horseman, and a notable whip. It is recorded of him that he once drove the mail coach from London to Haddington without leaving the box or resigning the reins for a single stage. Even in extreme old age he was to be seen on the streets of this city driving a pair of spirited horses with the vigour and skill of an experienced charioteer.

In 1842 the Marquis went out to India as Governor and Commander-in-Chief at Madras. Here he remained for six years faithfully discharging the duties of his high and responsible office. As one who had been trained under Wellington he could not but set himself to restrain and cure the lax discipline which had been allowed to creep into the Indian army; and the severity of some of the measures he took with this view exposed him to no small obloquy and censure. Events, however, proved that he was right in the course he pursued, and that his action was alike necessary and salutary.

On his retirement from active service in the army the Marquis devoted himself to the duties and occupations of a country gentleman, and these he continued to pursue to the end of his life with the exception of the six years he was in India. He engaged largely in agricultural pursuits, retaining in his own hands an extensive farm, which he cultivated with the utmost assiduity, sparing no expense of money, or labour, or skill, not only to render it productive to the highest possible degree, but to make it a model of scientific farming, from which others engaged in the same pursuit might derive profitable instruction. He introduced many important improvements both in the practice of farming and in the implements used in agriculture; so great, indeed, were the improvements he introduced, both in the methods and in the means of tillage, that he may be said to have revolutionised Scottish agriculture. In 1836 he received the gold medal of the Highland and Agricultural Society for the invention of a machine for

the making of tiles to be used in drainage. He invented also the Tweeddale plough, an implement which has been found of immense use, as enabling the cultivator with the minimum of draught to turn up the subsoil so as to break it up and subject it to the action of the atmosphere. The system of deep ploughing which he introduced prepared the way for the use of the steam-plough, which he was the first to bring under the notice of the Society and to introduce into general use. As has been justly said, "the agricultural world was under a deep obligation to the Marquis for the time, research, and large pecuniary expenditure he devoted to the practical solution of the steam plough question."*

To the agriculturist the condition and changes of the atmosphere are hardly of less interest than is the soil which he has to till. As might be expected, therefore, in one so interested in agriculture, the Marquis of Tweeddale attached great importance to meteorology, and devoted much time, labour, and money to the fostering of that science. Of the National Meteorological Society of Scotland he was from the first, and continued to be, the main support. From time to time he offered prizes for the best essay or series of observations on meteorological phenomena; which had the effect of engaging the attention of competent inquirers to these phenomena, and drawing forth some communications of the greatest importance to those engaged in agriculture and allied pursuits.

Besides holding the hereditary honours and dignities of his house, some of which had come down to him from a remote ancestry, Lord Tweeddale possessed many personal distinctions. He was a K.T. and G.C.B., a representative Peer of Scotland, Lord-Lieutenant of Haddingtonshire, Colonel successively of the 30th Regiment, the 42nd Regiment, and the 2nd Regiment of Life Guards, a General in the army, and a Field Marshal. He died at Yester House on the 10th of October last, in his 90th year.

The Marquis of Tweeddale became a Fellow of this Society in 1849.

Adolphe Pictet was born at Geneva on the 11th of September 1799. He received his education at the Hofwyl institution

* Stephens & Slight, Book of Farm Implements.

founded by Fellenberg, who was an intimate friend of his father Charles Pictet de Rochamont. He afterwards studied at Paris; and from that he went to Germany, where he made the acquaintance of Schlegel, Schelling, Hegel, and Goethe, as he had at Paris that of Victor Cousin and other men of eminence. A vast mass of letters remain to testify to the intimacy of his relations with these and other distinguished men among his contemporaries.

He began to write in the "Bibliotheque Universelle," a journal founded by members of his own family, and of which he became the proprietor in 1825. In 1838 or 1839 he commenced to lecture on æsthetics in the Academy at Geneva, and three years afterwards he was appointed professor there of æsthetics, modern literature and linguistic. This appointment he did not hold long; circumstances led to his engaging in other pursuits, and for a time he left Geneva and fixed his abode at Turin. Obliged, as every Swiss citizen is, to serve as a soldier, he for some time was in the army, where he rose to the rank of colonel of artillery. Directing his attention to the implements of artillery warfare, he introduced such improvements in these that the Austrian Government purchased for 25,000 francs the secret of bombs of his invention. Returning to Geneva, he devoted himself to his favourite studies, and from time to time issued works in various branches of philosophy, and especially in comparative philology, which brought him reputation much more in other countries than his own. In Geneva, indeed, he was very little known, the abstruse character of his writings rendering them acceptable only to the few, and the deafness with which he was afflicted preventing him from mingling in general society. In 1839 the Institute of France adjudged to him the Volney prize for an essay on the affinity of the Celtic language with the Sanscrit; and twenty years afterwards the same prize was assigned to him for a work in which he developed at length his views as to the primary relations of the Indo-European tongues generally. This work, which is entitled "Les Origines Indo-Européennes, ou Les Aryas primitifs; Essai de Paléontologie linguistique," is one of great learning and acuteness, and has commanded the applause of philologists and ethnologists in all parts of the learned world. In 1856 he published a work scarcely less remarkable in its kind, entitled "Du Beau dans la Nature, l'art, et

la poesie, études d'Esthétique." His other works are, "Course à Chamonix, conte fantastique" (1838); "Essai sur les propriétés et la tactique des fusées de guerre" (Turin, 1848); "Mystère des Bardes de l'Isle de Bretagne;" two "Essais sur des Inscriptions Gauloises," and many articles in reviews and other periodicals.

M. Pictet was a Member of the Royal Irish Academy, of the Ethnographic Society of New York, of the Academie Stanislas of Nancy, as well as a Fellow of this Society. From Napoleon III. he received the decorations of the Legion of Honour and of St Maurice and St Lazare. He was elected an Honorary Fellow in 1864. He died 20th December 1875.

Adolphe-Theodore Brongniart was born at Paris on the 14th January 1801. He was the son of Alexandre Brongniart, the celebrated naturalist and associate of Cuvier, who died in 1847. Devoted from childhood to the study of the natural sciences, in which he was encouraged as well by the example as by the counsels of his father, Adolphe, while preparing to take his degree of doctor of medicine, cultivated at the same time with earnestness and success botany and geology. In 1822 he published a monograph on the classification and distribution of fossil vegetables; three years later he published a work on *Champignons*, in which he embraced the whole of that family in a natural classification of its genera; and in 1826 he presented to the Académie des Sciences a "Memoire sur la génération et le dévéloppement de l'embryon végétal," for which he received the first prize for experimental physiology. In this work a new light was thrown on the most important fact in the life of plants; and if it cannot be said that he entirely lifted the veil which had hitherto covered the mystery of fecundation, he advanced very near to the complete explanation of that phenomenon. The course on which he had thus entered of scientific investigation he pursued with unabated energy to the close of his life. The number of investigations which he conducted, and the papers which he presented to scientific societies and to the scientific world through the press, indicate an almost unprecedented amount of activity on his part. His most important work is his "Histoire des Végétaux Fossiles," which unfortunately was left unfinished by him. In this work new light is thrown on both botany and

geology, and it may be regarded as a work of standard authority on vegetable palæontology.

M. Brongniart was elected professor of botany and vegetable physiology in the Museum of Natural History at Paris in 1833; and from 1852 he was inspector-general of the University for the sciences. He was a Member of the Academie des Sciences and an officer of the Legion of Honour. He was elected an Honorary Fellow of this Society in 1872. He died in February last.

CHRISTIAN GOTTFRIED EHRENBERG was born at Delitsch, in Prussia, on the 19th of April 1795. He studied chiefly at Leipsic, where he took his doctor's degree in medicine. At Berlin, in 1815, he devoted himself to microscopic researches in physiology, and through these became known to the scientific world. In 1820 he was sent by the Academy of Sciences, along with Hemprich, on a scientific expedition to Egypt, in the course of which he traversed Egypt, Abyssinia, and a considerable part of Africa. His companion having succumbed under the fatigues of the journey, Ehrenberg prosecuted it alone, and returned bringing with him a large collection of animals and plants until then unknown. He was named professor extraordinary in the Faculty of Medicine at Berlin; but he preferred going with Humboldt to explore Central Asia, and more particularly the plateau of the Altaï. On his return he settled at Berlin, where he was in 1842 made principal secretary to the Academy of Science. Here he devoted himself chiefly to microscopic researches on the Infusoria, and in this field made many discoveries, which added materially to the knowledge of these minute forms of animal life, and suggested the explanation of many previously unexplained phenomena, such as phosphorescence on the sea, blood-rain, red snow on the Alps, and the blood-red spots which, to the terror of the ignorant and superstitious, sometimes appear on bread. To the heaps of infusoria, also, he attributed "the existence of vegetable soil, and according to his observations these infinitely small creatures have formed entire mountain-chains, and played an important part in the formation of the crust of the earth."* His great work, entitled "Die Infusiorsthierchen als vollkommen Organismen" (Leipz. 1838), contains his classification

* Men of the Time, p. 328, 8th edit.

of these minute organisms, a classification, however, which naturalists have not universally adopted.

Herr Ehrenberg was a member of most of the learned Societies of Europe. He was elected an Honorary Fellow of this Society in 1845. He died in April of this year.

In the course of the past session the number of "papers" read at the meetings of the Society was forty-five, besides the address delivered at the opening of the session by the senior Vice-President, Mr Milne-Home. Of the papers read, twenty-three were in the department of mathematics and physics, three in chemistry, four in meteorology, one in anatomy, five in geology, two in geography, five in botany and natural history, and two on literary subjects. Some of these papers were of considerable length, and most were of importance and permanent interest.

The Keith Prize for the biennial period 1873–75 was awarded to Professor Crum Brown for his "Researches on the Sense of Rotation and on the Anatomical Relations of the Semi-Circular Canals of the Internal Ear;" and was presented to him by the President at the meeting on the 15th of May.

The Society is to be congratulated on the evidence which the number and variety of the papers read last session afford of the continued zeal and activity of its members in various spheres of scientific inquiry and literary research. At the same time, I venture to express a wish that the range of the Society's activity were widened, so that incursions were made into fields of inquiry and research which, so far as our Proceedings show, are wholly neglected by the members of the Society. With the exception of the two literary papers, all the papers read last session have to do either with the exact sciences or the sciences of observation. Besides these, however, there are the moral sciences, the science of experience or consciousness, and the history of science, in all of which there are questions of high interest and importance which yet remain unsettled, and which await and invite the investigation of members of a learned body such as this. How little, for instance, is known of the history of philosophic thought and scientific speculation among the Arabians and the Jews in the Middle Ages, or among the theosophists, mystics, and speculatists of the East!

In ethics, in political economy, in jurisprudence, in international law, how many points of profound interest are still in dispute or are involved in obscurity! In psychology, how many new theories and methods have recently emerged, both in this country and on the Continent, which may change the entire aspect of that science, and which, at any rate, challenge the careful consideration of all philosophic thinkers! A new science, indeed, has of late sprung up in this department,—the science, so-called, of physiological psychology,—an infelicitous designation, as I cannot but think, seeing that as physiology can never become psychology nor psychology physiology, the union of the two words in one designation is almost tantamount to a negation of the possibility of the science so designated. This science has found so many enthusiastic and able cultivators that its claims on the attention and study of scientific inquirers cannot be neglected. I confess I am not myself sanguine of any great advantage accruing to psychology from its being approached through the medium of physiology, for this, were there no other reason, that, as on the one hand, the physiologist must first learn from consciousness or experience the existence of any faculty before he can search for or find an organ for that faculty in the body; so, on the other hand, he is unable from the mere observation of the bodily organs or functions to throw any light upon the mental faculties, seeing all he can accomplish at the utmost is to point to a connection of some sort between the mental faculty and the bodily organ. At the same time, I defer to the judgment of the eminent men who have appeared as the cultivators of this science, and claim for it a place among the objects which engage the attention of the members of this Society.

"Through desire a man, having separated himself, seeketh and intermeddleth with all wisdom" (Prov. xviii. 1). This saying of the Hebrew sage might be adopted as a fitting motto for such a Society as this. By joining it the members separate or set themselves apart, under the impulse of a master desire, to the pursuit of knowledge; and it beseems them, as so separated, to take all wisdom for their province. It is true that in the present day knowledge is no longer confined to the few, or locked up within Societies of those who give themselves to the pursuit of it as their business and occupation. It is true that "science has now left her retreats,

her shades, her selected company of votaries" (Channing); and that many who are engaged in other occupations are at the same time diligent cultivators of science, and often come forward to add contributions to its stores. Still, it is to those who set themselves apart as men of science or as literary men that the world looks for the steady pursuit of knowledge, and for the guidance of others to the solution of those questions which from time to time press upon the interest or affect the welfare of the community. And where Societies of such are formed men look to them to intermeddle with all wisdom, and leave no part of the wide field of knowledge unexplored.*

On the value and utility of such Societies it would be idle in me to expatiate in such an assembly as this. Who knows not that by intercourse with others men have their faculties sharpened, are helped better to understand themselves, and to bring to precision and definiteness their own cogitations, as well as stimulated to explore new fields of inquiry and guided to make new discoveries? It is long ago since Homer said—

> " By mutual confidence and mutual aid
> Great deeds are done and great discov'ries made.
> The wise new wisdom from the wise acquire,
> And one brave hero fans another's fire"—†

and ample experience has showed that this holds true no less of those who go in quest of truth than of those who engage in military adventure; for as Plato, after referring to this passage in Homer, says, " in society we all are somehow more alert in deed and word and thought;"‡ and Aristotle, also referring to this passage, says that by society "those engaged in great undertakings are rendered more potent to think and to act."§ I content myself with congratulating the Society on its past achievements and its present flourishing condition; and expressing my confidence that the energy which has characterised the members in the past will be no less displayed, and with equally satisfactory results, during the session on which we now enter.

* Naturæ rerum vis atque majestas in omnibus momentis fide caret si quis modo partes ejus ac non totam complectitur animo.—Plin. Hist. Nat. vii. 1.

† Iliad, x. 265, in Pope's version.

‡ Protag., p. 348, D. § Nicom. Eth., viii. 1.

We need have no misgivings as to the worthiness of the pursuits to which this Society is devoted. To search after truth, to strive, as "the minister and interpreter of Nature," not only to discover all her facts but to elicit their meaning, to educe the principles which underlie them, and to arrive at the apprehension of the laws which they obey,—

"Und was in schwankenden Erscheinung schwebt
Befestigen mit dauerden Gedanken"*—

is an occupation than which none can be more noble, more worthy of the faculties with which we have been endowed, or more pleasing to Him by whom these faculties have been conferred,—for He Himself is Truth; and in proportion as men with sincerity and earnestness seek after truth, in that proportion do they put on the similitude of God and come into sympathy with Him. The visible universe, moreover, is as Goethe has expressed it, "Der Gottheit lebendiger Kleid" (the living mantle of the Deity); and by it He, who is himself invisible, reveals himself to us, making known to us, as the apostle tells us, by the things that are made his eternal power and Godhead (Rom. i. 20). Philosophy, if it follow its normal tendency, leads up to God; for the progress of all true philosophic thought is from the many to the one, from facts to principles, from the relative to the absolute, from phenomena to essence; and it is illegitimately arrested in its proper course, and defrauded of its proper issue, if it be stopped short of the Supreme Essence in whose infinite mind are the archeal types of all existences—"the forms eternal of created things." Nor is the value of literary and scientific study as a moral discipline to be overlooked. To those engaged in such pursuits there arises an influence which, like some subtle essence, pervades their whole inner nature, and unconsciously, perhaps, to themselves elevates, purifies, and refines it. The study of philosophy, of literature, and of science thus becomes a great moral therapeutic, an instrument of spiritual culture:—"Animum format et fabricat, vitam disponit, actiones regit, agenda et omittenda demonstrat, sedit ad gubernacubum et per ancipitia fluctuentium dirigit cursum."†

"The true philosopher (I use the words of Sir Humphry Davy) sees good in all the diversified forms of the external world. Whilst

* Goethe, Faust, Prol. † Seneca, Ep. xvi.

he investigates the operations of infinite power guided by infinite wisdom all low prejudices, all mean superstitions disappear from his mind. He sees man an atom amidst atoms fixed upon a point in space, and yet modifying the laws that are around him by understanding them; and gaining, as it were, a kind of dominion over time and an empire in material space, and creating on a scale infinitely small a power seeming a sort of shadow or reflection of a creative energy, and which entitles him to the distinction of being made in the image of God and animated by a spark of the Divine mind." *

The following statement, in regard to the number of the present Fellows of the Society, has been drawn up by the Secretary:—

1. Honorary Fellows:—

*Royal Personage—*

His Royal Highness the Prince of Wales, . . 1

*British Subjects—*

John Couch Adams, Esq., Cambridge; Sir George Biddell Airy, Greenwich; Thomas Andrews, M.D., Belfast (Queen's College); Thomas Carlyle, Esq., London; Arthur Cayley, Esq., Cambridge; Charles Darwin, Esq., Down, Bromley, Kent; John Anthony Froude, Esq., London; Thomas Henry Huxley, London; James Prescott Joule, LL.D., Cliffpoint, Higher Broughton, Manchester; William Lassell, Esq., Liverpool; Rev. Dr Humphrey Lloyd, Dublin; William Hallowes Miller, LL.D., Cambridge; Richard Owen, Esq., London; Thomas Romney Robinson, D.D., Armagh; Lieut.-General Edward Sabine, R.A., London; Henry John Stephen Smith, Oxford; George Gabriel Stokes, Esq., Cambridge; James Joseph Sylvester, LL.D., London; William Henry Fox Talbot, Esq., Lacock Abbey, Wiltshire; Alfred Tennyson, Esq., Freshwater, Isle of Wight. . . . . . . . . . 20

*Foreign—*

Claude Bernard, Paris; Robert Wilhelm Bunsen, Heidelberg; Michael Eugene Chevreul, Paris; James D. Dana, LL.D., Newhaven, Connecticut; Heinrich Wilhelm Dove, Berlin; Jean Baptiste

Carry forward, 21

* Consolation in Travel, Works, vol. ix. p. 361.

Brought forward, 21

Dumas, Paris; Charles Dupin, Paris; Elias Fries, Upsala; Herman Helmholtz, Berlin; August Kekule, Bonn; Gustav Robert Kirchhoff, Heidelberg; Herman Kolbe, Leipzig; Albert Kölliker, Wurzburg; Ernst Eduard Kummer, Berlin; Johann von Lamont, Munich; Richard Lepsius, Berlin; Ferdinand de Lesseps, Paris; Rudolph Leuckart, Leipzig; Urbain Jean Joseph Leverrier, Paris; Joseph Liouville, Paris; Carl Ludwig, Leipzig; Henry Milne-Edwards, Paris; Theodore Mommsen, Berlin; John Lothrop Motley, United States; Louis Pasteur, Paris; Prof. Benjamin Peirce, United States Survey; Henry Victor Regnault, Paris; Angelo Secchi, Rome; Karl Theodor von Siebold, Munich; Bernard Studer, Berne; Otto Torell, Lund; Rudolph Virchow, Berlin; Wilhelm Eduard Weber, Gottingen; Friedrich Wohler, Gottingen, . . . . . . . . . . . 34

The following are the Honorary Fellows deceased during the year:—

*British*—Sir William E. Logan.

*Foreign*—Adolphe-Theodore Brongniart, Christian Gottfried Ehrenberg.

2. Non-Resident Fellow under the Old Laws:—

Sir Richard Griffiths, . . . . . . . . 1

Total Honorary and Non-Resident Fellows at 4th December 1876, . . . . . . . . . 56

3. Ordinary Fellows:—

Ordinary Fellows at November 1875, . . . . . 358

*New Fellows*, 1875–76.—Rev. Francis Edward Belcombe; Bruce Allen Bremner, M.D.; Rev. John Gibson Cazenove, D.D.; Peter Denny; James Douglas H. Dickson, M.A.; James Duncan; J. S. Fleming; J. Ballantine Hannay; M. Forster Heddle; Rev. Norman Macleod, D.D.; John Macmillan, M.A.; J. F. Rodger, S.S.C.; William Skinner, W.S.; William Thomson, F.C.S.; Rev. Francis Le Grix White, M.A., . . . . . . . . . . 15

Carry forward, 373

| | | |
|---|---|---|
| | Brought forward, | 373 |
| *Deduct Deceased*—Dr James Warburton Begbie; David Bryce; G. Stirling Home Drummond; Lewis D. B. Gordon, C.E.; Sir George Harvey; Dr Laycock; Thomas Login, C.E.; Alexander Russel; The Marquis of Tweeddale, . . . . . . . . . . . . . | 9 | |
| *Resigned*—Hon. Charles Baillie (Lord Jerviswoode) . | 1 | |
| | | 10 |
| Total number of Ordinary Fellows at November 1876, . | | 363 |
| Add Honorary and Non-Resident Fellows, . . | | 56 |
| Total Honorary and Ordinary Fellows at commencement of Session 1876–77, . . . . . . . . | | 419 |

*Monday, 18th December* 1876.

SIR WILLIAM THOMSON, President, in the Chair.

The following Communications were read:—

1. On the Roots of the Equation V $\rho\phi\rho = 0$. By Gustav Plarr. Communicated by Professor Tait.

2. Applications of the Theorem that Two Closed Plane Curves intersect an even number of times. By Prof. Tait.

(*Abstract.*)

The theorem itself may be considered obvious, and is easily applied, as I showed at the late meeting of the *British Association*, to prove that in passing from any one double point of a plane closed curve continuously along the curve to the same point again, an *even* number of intersections must be passed through. Hence, if we suppose the curve to be constructed of cord or wire, and restrict the crossings to *double points*, we may arrange them throughout so that, in following the wire continuously, it goes alternately over and under each branch it meets. When this is done it is obviously as completely knotted as its scheme (defined below) will admit of, and except in a special class of cases cannot have the number of crossings reduced by any possible deformation. The excepted class is that in

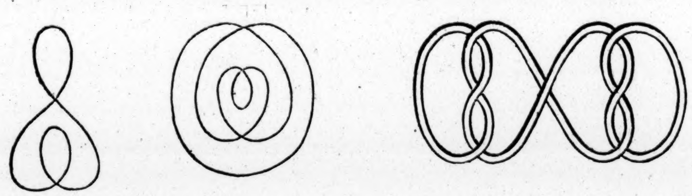
which the intersections are either wholly or partially nugatory, *i.e.*, not in reality contributing to the knot, whether on account of the order of their arrangement or their signs. All nugatory intersections can be detected at once by the scheme itself, and may be struck out. As will be understood from what follows, the schemes

A A B B C C and A C B B C A

are wholly nugatory, while in

A C B D C B D A E G F E G F

only the intersection A is necessarily nugatory. In fact a group like C B D C B D, when not itself nugatory by reason of its signs, is self-contained, and forms a special knot which may be drawn tight so as to present only a roughness in the string. The following sketches illustrate these essentially nugatory crossings:—



I. Given the number of its double points, to find all the essentially different forms which a closed curve can assume.

(*a*.) Going round the curve continuously, call the first, third, &c., intersections A, B, C, &c. In this category we evidently exhaust all the intersections. The complete scheme is then to be formed by properly interpolating the same letters in the even places; and the form of the curve depends solely upon the way in which this is done.

(*b*) It cannot, however, be done at random. For instance, the scheme

A*D*B*E*C*A*D*B*E*C* | A

is lawful, but

A*D*B*A*C*E*D*C*E*B* | A

is not.

The former, in fact, may be treated as the result of superposing two closed (and not self-intersecting) curves, both denoted by the letters A D B E C A, so as to make them cross one another at the points marked B, C, D, E, then cutting them open at A, and joining the free ends so as to make a continuous circuit with a crossing at A.

But in the latter scheme above, we have to deal with the curves A D B A and C E C E, and in the last of these we cannot have the junctions alternately + and − as required by our fundamental principle. In fact, the scheme would require the point C to lie simultaneously inside and outside the closed circuit A D B A.

Or we may treat A D B A and C E D C as closed curves intersecting one another and yet having only one point, D, in common.

(*c*) Thus, to test any arrangement, we may strike out from the whole scheme all the letters of any one closed part as A——*A*, and the remaining letters must satisfy the fundamental principle.

Or we may strike out all the letters of any two sets which begin and end similarly, *e.g.*, A . . . X, X . . . A, the two together being treated as one closed curve, and the test must still apply.

More generally, we may take the sides of any closed polygon as A – X, X – Y, Y – Z, Z – A, and apply them in the same way. But in this, as in the simpler case just given, the sides must all be taken the same way round in the scheme itself.

(*d.*) Such schemes as the latter of the two in (*b*) above may be made algebraically possible by slightly changing our assumptions. Thus, for instance, we might admit of a triple point, and agree not to reckon it as an intersection on a continuous oval provided one of the remaining branches goes *into* the oval, and the other comes out of it, these two not necessarily intersecting one another. In the case specified the triple point would be E supposed to lie *on* the oval A D B A, and not to be counted as an intersection while we pass round that oval. But this is a mere algebraic escape from a geometrical difficulty, and will not necessarily help us when we deal with knots on actual cords or wires.

II. A possible scheme being thus made, with the requisite number of intersections, let it be constructed in cord, with the intersections as above alternately + and −. Then [since all schemes involving nugatory points, like those above mentioned, must be got rid of, as they do not really possess the requisite number of intersections] no deformation which the cord can suffer will reduce, though it may increase, the number of double points. If it *do* increase the number, the added terms will be of the nugatory character presently to be explained. If it do not increase that number, the scheme will in general still represent the altered

figure. Hence the scheme is a complete and definite statement of the nature of the knot.

(*a*.) One illustration depends upon the fact that all deformations of such a cord or wire may be considered as being effected by bending at a time only a limited portion of the wire, the rest being held fixed. This corresponds to changing the point of view *finitely* with regard to the part altered, and yet *infinitesimally* with regard to all the rest. This, it is clear, can always be done, as the *relative* dimensions of the various coils may be altered to any extent without altering the character of the knot. All such deformations may be obtained by altering the position of a luminous *point*, and the plane on which it casts a shadow of the knot. Any addition to the normal number of intersections which may be produced by this process is essentially nugatory.

Another mode, really depending on the same principles, consists in fixing temporarily one or more of the crossings, and considering the impossibility of unlocking in any way what is now virtually two or more *separate* interlacing closed curves, or a single closed curve with full knottings, but with fewer intersections than the original one.

Another depends upon the study of cases of knots in which one or more crossings can be got rid of. Here, it is proved that *continuations* of sign are in general lost when an intersection is lost; so that, as our system has no continuations of sign, it can lose no intersections.

(*b*.) Practical processes for producing all such deformations graphically are given at once by various simple mechanisms. Thus, taking O any fixed point whatever, let $p$, a point in the deformed curve, be found from its corresponding point, P, by joining PO and producing it so that

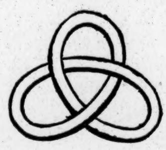
$$\mathrm{PO}\cdot\mathrm{O}p=a^2,$$

or so that

$$\mathrm{PO}+\mathrm{O}p=a, \text{ \&c., \&c.}$$

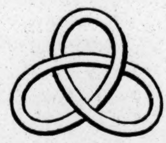
The essential thing is that points near O should have images distant from O, and *vice versâ*. And $p$ must be taken in OP *produced*, else the distorted knot is altered from a right-handed to a left-handed one, and *vice versâ*. This distinction is shown in the cuts

1 and 3 below, where it will be seen that one turn of the coil may be regarded as wound round the other—the screw being right-handed in 3 and left-handed in 1.



1.

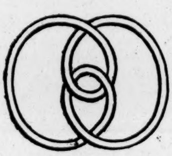
2.



3.

It is easy to show that these methods give merely different views of the same knot. The simplest way of doing this is to suppose the knot projected on a sphere, the eye being at the centre. Arrange so that one closed branch, *e.g.*, A——A, forms nearly a great circle. Shifting the eye to opposite sides of the plane of this great circle the coil presents exactly the two appearances related to one another by the deformation processes given above. What was inside the closed branch from the one point of view is outside it from the other, and *vice versâ.*

Thus 1 and 2 above are the *only* forms with three non-nugatory intersections. 2 may be formed from 1 by putting O in either of the three border areas, each of which has two sides only. If O be placed in external space, or in the inner three-sided area, 1 is reproduced. Similar remarks apply to the deformation of 2.



4.

5.

Figures 4 and 5 are the only forms with four valid intersections. Like 1 and 2, the first of them is a *clear* coil (see below), the second not clear. And, of course, any deformation of either produces the other, or reproduces itself. 6, 7, 8, 9, are forms of an essentially not-clear arrangement, with five intersections. The numbers inserted in 6 show which form is produced by placing O in the corresponding area. The only other forms having five intersec-

tions, are the clear coil of two turns, whose scheme is the first given in I (*b*) above, and its solitary deformation.


6.


7.


8.


9.

(*c*.) Hence to draw a scheme, select in it any closed circuit, *e.g.*, A . . . . A—the more extensive the better, provided it do not include any less extensive one. Draw this, and build upon it the rest of the scheme; commencing always with the common point A, and passing each way from this to the *next occurring* of the junctions named in the closed circuit. [It is better to construct both parts of the rest of the scheme *inside*, and then invert one of them, as we thus avoid some puzzling ambiguities.] Inversions with respect to various origins will now give all possible forms of the scheme.

III. Thus the scheme is perfectly definite as to the general shape of the curve, if we take the possible deformations into account. And the spherical projection, already mentioned, will in general allow us to regard and exhibit the knot as a more or less perfect *plait*. It does so always when the coil is *clear*, *i.e.*, when all the turns of the cord may be regarded as passing in the same direction round a common axis thrust through the knot. When the coil is not clear some of the cords of the plait are doubled back on themselves. Thus by drawing the plait from a given scheme we can tell at once whether one of its forms is a clear coil or not.

From this point of view another notation for clear coils is given in the form

$$\begin{matrix} \alpha\,\gamma\,\beta\,\alpha \\ \beta\,\alpha\,\gamma\,\beta \end{matrix} \cdots\cdots$$

Here $\alpha$, $\beta$, $\gamma$ . . . are, in order, the several strings plaited—so that in the coil $\beta$ is the prolongation of $\alpha$, $\gamma$ that of $\beta$, &c., and $\alpha$ that of the last of the series. The expression $\begin{matrix}\alpha\\ \beta\end{matrix}$ means that $\alpha$ crosses *over* $\beta$. It is sometimes useful to indicate whether a crossing takes place to the right or left. This is done by putting + or − over the symbol. Thus the four crossings above may be more fully written as

$$\begin{matrix} + & - & + & - \\ \alpha & \gamma & \beta & \alpha \\ \beta & \alpha & \gamma & \beta \end{matrix} \; \cdots\cdot$$

The properties of this notation are examined in detail. It is shown, that the combination just written cannot be simplified in itself; but that

$$\begin{matrix} + & - & - & - \\ \alpha & \gamma & \gamma & \alpha \\ \beta & \alpha & \beta & \beta \end{matrix} = \begin{matrix} - & - \\ \gamma & \gamma \\ \beta & \alpha \end{matrix}, \text{ \&c.}$$

This notation requires care. For instance, the terms

$$\begin{matrix} \alpha & \alpha \\ \beta & \beta \end{matrix}$$

are simply nugatory, and may be written off. But, on the other hand, the terms

$$\begin{matrix} \alpha & \beta \\ \beta & \alpha \end{matrix}$$

usually add to the beknottedness of the whole scheme.

When the scheme is not compatible with a clear coil there occur terms of the form

$$\begin{matrix} \alpha \\ \alpha \end{matrix},$$

and the application of this method becomes very troublesome.

(*a*.) When the scheme has no merely nugatory intersections, the most complete knotting is secured by alternate crossings above and below; or, as we may write,

$$\begin{matrix} A & X & B & Y & C \\ + & - & + & - & + \end{matrix} \; \ldots \; \text{\&c.}$$

and here there is *no continuation of sign.*

(*b*.) Cases in which there is no knot at all may be obtained for any scheme by making each letter positive on its first appearance. The various coils are then, as it were, paid out over one another. This process will give rise, in general, to but few changes of sign:

but the number of such will usually depend upon the particular intersection with which we commence the scheme.

Additional changes of sign, still without any knotting, may be introduced by various processes, of which the following is the simplest:—When two letters appear together twice, not necessarily in the same order, but with like signs, these signs may be changed. Thus, the following parts of a scheme

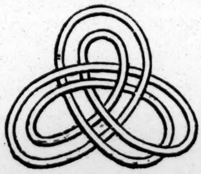
$$\begin{array}{cccc} P\,Q & \ldots\ldots & Q\,P \\ -\,- & & +\,+ \end{array}$$

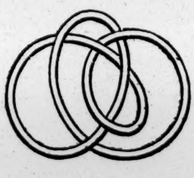
may be changed to

$$\begin{array}{cccc} P\,Q & \ldots\ldots & Q\,P \\ +\,+ & & -\,- \end{array}$$

and the statements already made about nugatory intersections can be applied to these and other combinations even when they occur separately once only in each of two separate knots on the same cord. This, and a great number of similar theorems, allow of a great special extension of the nugatory test already given—but an extension which cannot be made in any case until the *signs* of the intersections are given as well as the order of their occurrence.

Again, though, as has been said above, continuations of sign disappear when an intersection is lost, it does not follow that if a scheme have continuations of sign it must necessarily be reducible. The annexed diagram is an excellent instance. Its scheme contains fourteen continuations, and only twelve changes, of sign, and yet the knot is irreducible. But if we suppose it cut across twice at the single unsymmetrically placed crossing, and the ends joined so as still to preserve continuity in the string, the scheme has still fourteen continuations, but only ten changes, of sign; and it does not involve any real beknottedness.





The remaining figure illustrates a fully knotted scheme, where there are no continuations of sign, but in which the mere change of sign of one of the intersections produces four continuations of sign, and the whole beknottedness disappears. Similar remarks apply to most of the preceding figures.

IV. A great many other deductions from the fundamental proposition are given—for instance,

A closed plane curve, intersecting itself, divides the plane into separate areas whose number is greater by 2 than the number of intersections.

Regarding the curve as a wall, dividing the plane into a number of fields, if we walk along the wall and drop a coin into each field as we *reach* it, each field will get as many coins as it has corners, but those fields only will have a coin in each corner whose sides are all described in the same direction round. The number of coins is four times the number of intersections—and two coins are in each corner bounded by sides by each of which you enter—none in those bounded by sides by each of which you leave.

Cut off at any intersection and remove a portion of the curve forming a closed (not self-cutting) circuit. You thus abolish an odd number of intersections. Hence if there is an even number of coils, whether the whole be clear or not, there is an odd number of intersections, and *vice versâ*.

To form the symmetrical clear coil of two turns and of any (odd) number of intersections, make the wire into a helix, and bring one end through the axis in the same direction as the helix (not in the opposite direction, as in Ampère's *Solenoids*), then join the ends. [The solenoidal arrangement, regarded from any point of view, has only nugatory intersections.] An excellent mode of forming this coil is to twist a long strip of paper through an odd number of half-turns, and then paste its ends together,—the two longer edges become parts of one continuous curve which is the clear coil in question. This result is applied to the study of the form of soap-films obtained by Plateau's process on clear coils of wire.

V. Another question treated is the numbers of possible arrangements of given numbers of intersections in which the *cyclical* order of the letters in the 2nd, 4th, 6th, &c. places of the scheme shall be the same as that in the 1st, 3rd, 5th, &c., *i.e*, the alphabetical. Instances of such have already been given above. In the first of I (*b*), for example, the letters in the even places are

D E A B C.

Here the cyclical order of the alphabet is maintained, but A is postponed by two places.

Whatever be the number of intersections a postponement of *no* places leads to nugatory results.

A postponement of one place is possible for three and for four intersections only.

Postponement of two places is possible only for (*four*), five, and eight—three for seven and ten—four for nine and fourteen—five for (*eight*), eleven and sixteen,—six for (*ten*), thirteen, and twenty, &c. Generally there are in all cases $n$ postponements for $2n+1$ intersections:—and for $3n+2$, or $3n+1$ intersections, according as $n$ is even or odd. The numbers which are italicised and put in brackets above, arise from the fact that a postponement of $r$ places, when there are $n$ intersections, gives the same result as a postponement of $n-r-1$ places. [It will be observed that this cyclical order of the letters in the even places is possible for *any* number of intersections which is not 6 or a multiple of 6.]

When there are $n$ postponements with $2n+1$ intersections the curve is the symmetrical double coil—*i.e.*, the plait is a simple *twist*.

The case with $3n+2$ or $3n+1$ intersections is a clear coil of three turns, corresponding to a regular plait of three strands.

VI. Numerous examples are given of the application of various methods of reduction. For instance, the scheme

$$\begin{array}{c}\mathrm{A}\,E\,\mathrm{B}\,F\,\mathrm{C}\,G\,\mathrm{D}\,A\,\mathrm{E}\,K\,\mathrm{F}\,L\,\mathrm{G}\,D\,\mathrm{H}\,B\,\mathrm{K}\,C\,\mathrm{L}\,H \mid \mathrm{A}\\ -\,+\,+\,+\,-\,+\,-\,+\,-\,+\,-\,+\,-\,+\,-\,-\,-\,+\,-\,+\end{array}$$

which is rendered irreducible by changing the sign of B, is reduced by successive stages as follows:—

$$\begin{array}{c}\mathrm{A}\,\mathrm{B}\,\mathrm{C}\,G\,\mathrm{D}\,A\,K\,L\,\mathrm{G}\,D\,\mathrm{H}\,\mathrm{K}\,B\,C\,\mathrm{L}\,H \mid \mathrm{A},\\ -\,+\,-\,+\,-\,+\,+\,+\,-\,+\,-\,-\,-\,+\,-\,+\end{array}$$

$$\begin{array}{c}\mathrm{B}\,\mathrm{C}\,\mathrm{A}\,G\,\mathrm{D}\,A\,\mathrm{G}\,D\,\mathrm{H}\,B\,C\,H \mid \mathrm{B},\\ +\,-\,-\,+\,-\,+\,-\,+\,-\,-\,+\,+\end{array}$$

$$\begin{array}{c}\mathrm{C}\,\mathrm{A}\,G\,\mathrm{D}\,A\,\mathrm{G}\,D\,C \mid \mathrm{C};\\ -\,-\,+\,-\,+\,-\,+\,+\end{array}$$

and, finally,

$$\begin{array}{c}\mathrm{A}\,G\,\mathrm{D}\,A\,\mathrm{G}\,D \mid \mathrm{A},\\ -\,+\,-\,+\,-\,+\end{array}$$

which is the simple irreducible knot of figures 1 and 3 above.

## 3. On the Distribution of Volcanic Débris over the Floor of the Ocean,—its Character, Source, and some of the Products of its Disintegration and Decomposition. By John Murray, Esq. Communicated by Sir C. Wyville Thomson.

During the present session I propose to lay before the Society several papers on subjects connected with the deposits which were found at the bottom of the oceans and seas visited by H.M.S. Challenger in the years 1872, 1873, 1874, 1875, and 1876.

*Instruments in use for obtaining information of the Deposits.*

It will be convenient to introduce this first communication with a brief description of the instruments and methods employed on board H.M.S. Challenger with the view of obtaining information and specimens of these ocean deposits. The instrument in most frequent use was the tube or cylinder forming part of the sounding apparatus.

During the first six months of the cruise this cylinder was one having less than an inch bore, and was so arranged with respect to the weights or sinkers that it projected about six inches beneath them. The lower end of the cylinder was fitted with a common butterfly valve. This arrangement gave us a very small sample of the bottom.

In July 1873 this small cylinder was replaced by one having a two-inch bore, and it was also made to project fully eighteen inches below the weights. This was a great improvement, as it gave a much greater quantity of the bottom in most soundings.

The tube was, in the clays, frequently forced nearly two feet into the bottom. On its return to the ship, the butterfly valves were removed, and a roll of the clay or mud, sometimes eighteen inches in length, could be forced from it. In this way we learned that the deeper layers were very frequently different from those occupying the surface.

In the organic oozes—as the Globigerina, Pteropod, Radiolarian, and Diatom oozes—the tube did not usually penetrate the bottom over six or seven inches, these deposits offering more resistance than the clays and muds. Occasionally the tube came up without anything in it, but the outside was marked with streaks of the black

oxide of manganese. In about thirteen out of nearly four hundred soundings we did not get any information of a reliable nature about the deposit.

The dredge in use was a heavy modification of Ball's naturalists' dredge, and the trawl was the ordinary beam trawl of the fishermen.

Both of these instruments had generally a bag of canvas or other coarse cloth sewed into the bottom of the netting, to prevent the soft clay or ooze from being entirely washed out. In this way we, at many stations, got, along with animals, a large quantity of ooze, clay, stones, or manganese nodules.

While trawling or dredging the ship often shifted her position a mile or two, but we could not tell whether the dredge or trawl had been working over all that distance, or had merely taken a dip into the deposits. This should be remembered when comparing the captures in one locality with those of another.

Altogether there is much uncertainty about the behaviour of the trawl and dredge in deep water. It occasionally happened that when the greatest care was taken, and when it was believed that the trawl had been dragging for some hours, it came up without anything in it, or any evidence upon it or in the attached tow-nets to show that it had been on the bottom.

During the last year of the cruise a tow-net was attached to the dredging line just below the weights, which last were placed a few hundred fathoms in front of the trawl or dredge. Tow-nets were also attached to the trawl and dredge. These nets frequently came up nearly full of mud, and almost always contained minute things and fragments from the surface layers of the bottom.

At times the water-bottle attached to the sounding line came up with clay or ooze in it, or had some of the deposit adhering to its under-surface.

These then were the means and methods employed for getting information concerning ocean deposits, and collectively they have furnished us with a large amount of material. A careful examination of the specimens procured has already much increased our knowledge of the nature and distribution of ocean deposits, of the sources of the materials of which they are built up, and of the chemical processes taking place in the deep waters and on the floor of the ocean.

*The Volcanic Debris in Ocean Deposits and some of the Products of its Disintegration and Decomposition.*

In a preliminary report to Professor Wyville Thomson, which has been published in the Proceedings of the Royal Society of London, I pointed out the wide-spread distribution of volcanic debris in ocean deposits and its probable influence in the formation of deep sea clays, and manganese nodules or depositions. In this paper I propose to treat of these subjects in more detail, and to give some of the results of observations which have been made since the above report was written.

*Pumice Stones.*

The form of volcanic debris most frequently met with in ocean deposits is pumice stone.

Specimens of these stones, varying from the size of a pea to that of a foot-ball, have been taken in dredging at eighty of our stations. I have placed the position of these stations on a map, from which it will be seen that they occur all along our route.

Near volcanic centres the dredge has frequently brought them up in great numbers, as off the Azores in the Atlantic, off New Zealand and the Kermadec Islands, at several places among the Philippine Islands, off the coast of Japan, and elsewhere. As a rule, they are not numerous in shore deposits when these are distant from volcanic regions. In deposits far from land they are most abundant in deep-sea clays, from which the shells and skeletons of surface organisms have been all or nearly all removed.

In the North Pacific the trawl brought up bushels of them from depths of 2300 and 2900 fathoms. Perhaps in no single instance have we trawled successfully on any of our deep-sea clays without getting numbers of these stones. If there be an exception it is in the North Atlantic. But here it is to be remembered that while we were investigating the conditions of the North Atlantic our attention had not yet been directed to the importance of detecting the presence of pumice, and we have not preserved such large samples of the North Atlantic deposits as of those of other regions.

On the whole, pumice stones are more numerous in the Pacific than in the Atlantic deposits.

In the Globigerina and other organic oozes, they are abundan

or otherwise according as the deposit is near or far removed from volcanoes. In these oozes they never occur so abundantly as in the clays. They are more or less masked and covered up by the accumulated remains of foraminifera, diatoms, or other surface organisms. In like manner they are obscured in shore deposits by river and coast detritus. Besides those specimens which are sufficiently large to be examined by the hand, we detected with the microscope minute particles of feldspar in all our ocean deposits.

An inspection of the specimens which I have placed on the table will show that the majority of these pumice stones have a rolled appearance. Some of them have undergone much decomposition, while others are little altered. Some are coated with the peroxide of manganese, or have streaks of this substance running through them. They are the most frequent nucleus of the manganese nodules, to which I shall presently refer. Some specimens which were dredged from a depth of over three miles will, when dried, float for weeks in a basin of water; others, which have undergone partial decomposition, sink at once.

They present a great variety of texture and composition. They are white, grey, green, or black in colour. They are highly vesicular, or rather compact and fibrous. There would appear to be every gradation from common feldspathic to dark green pyroxenic kinds.

We find in them crystals of sanidin, augite, hornblende, olivine, quartz, lucite, magnetite, and titaniferous iron. Magnetic iron ore was found in all the specimens examined, either in crystals or in the form of dust. The other minerals vary in kind and abundance in the different specimens. The same crystals which we find in the pumice occur in all the kinds of ocean deposits.

*Sources of the Pumice Stones.*

The pumice stones which we find at the bottom of the sea have most likely all been formed in the air. Some of them may have fallen upon the sea; but the great majority seem to have fallen on land, and been subsequently washed and floated out to sea by rains and rivers. After floating about for a longer or shorter time they have become water-logged and have sunk to the bottom. Both in the North Atlantic and Pacific small pieces of pumice were several times taken on the surface of the ocean by means of the tow-net.

Over the surface of some of these serpulæ and algæ were growing, and crystals of sinadin projected, or were imbedded in the feldspar. During our visit to Ascension there was a very heavy fall of rain, such as had not been experienced by the inhabitants for many years. For several days after, many pieces of scoriæ, cinders, and the like were noticed floating about on the surface of the sea near the island. Such fragments may be transported to great distances by currents.

On the shores of Bermuda, where the rock is composed of blown calcareous sand, we picked up fragments of travelled volcanic rocks. The same observation was made by General Nelson at the Bahamas. Mr Darwin noticed pieces of pumice on the shore of Patagonia, and Prof. L. Agassiz and his companions noticed them on the reefs of Brazil. During a recent eruption in Iceland, the ferry of a river is said to have been blocked for several day by the large quantity of pumice floating down the river and out to sea. All the pumice which we find need not be of quite recent origin. Mr Bates informs me that great quantities of pumice are continually being floated down the Amazon. These come from near the foot of the Andes, where the head-waters cut their way through fields of pumice stones. In the province of Wellington, New Zealand, two of the rivers run through areas covered with pumice, and during floods bear great quantities out to sea.

Prof. Alex. Agassiz has kindly furnished me with the following note:—

"The river Chile, which flows through Arequipa, Peru, has cut its way for some thirty miles through the extensive deposits of volcanic ashes which form the base of the extinct volcano Misti. Some of the gorges are even 500 feet in depth, forming regular cãnons. The whole length of the river bottom is covered by well-rolled pieces of pumice from the size of a walnut to that of a man's head. In the dry season (winter) there is but little water flowing, but in the summer, or rainy season, the river, which has a very considerable fall (7000 feet in a distance of about 90 miles), drives down annually a large mass of these rolled pumice stones to the Pacific. The volcanic ashes are not recent. There is no tradition among the Indians of any eruption within historic times."

Captain Evans, the present hydrographer to the navy, informs

me that he frequently picked up pumice on the Great Barrier Reef of Australia.

### *Volcanic Ashes.*

Near volcanic centres, and sometimes at great distances from land, we find much volcanic matter in a very fine state of division at the bottom of the sea. This consists of minute particles of feldspar, hornblende, augite, olivine, magnetite, and other volcanic minerals. In the South Pacific, many hundred miles from land, and from a depth of 2300 fathoms, the trawl brought up a number of pieces of tufa entirely composed of these comminuted fragments. These particles appear to me to have been carried to the areas where we find them, by winds, in the form of what is known as volcanic dust or ashes. Sir Rawson Rawson sent to Sir Wyville Thomson a packet of the volcanic ashes which fell on the Island of Barbadoes, after an eruption in 1812 on the Island of St Vincent, W. I., one hundred and sixty miles distant. I have examined this, and find it made up of fragments of the same character as those in the tufa to which I have just referred, some of the particles being perhaps a little larger. We have sometimes found this ash in considerable abundance mixed up with the shells in a globigerina ooze. In the deposits for hundreds of miles about the Sandwich Islands there are many fragments of pyroxenic lava, which I believe have been borne by the winds, either as ashes, or in the form of Pele's hair.

At Honolulu we were informed that threads of Pele's hair were picked up in the gardens there after an eruption of Kilauea, one hundred and eighty miles from the volcano. This Pele's hair bears along with it small crystals of olivine.

### *Obsidian and Lava Fragments.*

Small pieces of obsidian and of feldspathic and basaltic lavas were frequently found in deposits near volcanic islands.

At two stations in the South Pacific, many hundred miles from land, we dredged pieces of this nature of considerable size larger than ordinary marbles. It is difficult to account for the transference of these fragments to the places where they were found. It is, however, in this region, and this alone, that it may be necessary to bring in a submarine eruption to account for the condition of things at the bottom.

A consideration of these observations, and the specimens which are laid on the table, will, I think, justify the conclusion that volcanic materials, either in the form of pumice-stones, ashes, or other fragments, are universally distributed in ocean deposits.

They have been found abundantly or otherwise in our dredgings, according as these have been near or far from volcanoes, or as there has been much or little river and coast detritus, or few or many remains of surface organisms in the deposits.

*Some of the Products of the Decomposition of Volcanic Debris.*

*Clay.*—Pure clay, as is well known, is a product of the decomposition of feldspar, and the clay which we find in ocean deposits appears to have had a similar origin.

In the deposits far from land the greater part of the clay originates, I believe, from the decomposition of the feldspar of fragmental volcanic material, which we have seen to be so universally distributed.

Pumice-stone is largely made up of feldspar, and from its areolar structure is peculiarly liable to decomposition. Being permeated by sea water holding carbonic acid in solution, a part of the silica and the alkalies are carried away, water is taken up, and a hydrated silicate of alumina or clay results.

Like most clays our ocean clays contain many impurities, these last being as varied as the sources whence the materials of the deposits are derived.

Let us briefly enumerate the sources of these materials.

We have *first* the matters derived from the wear of coasts, and those brought to the sea by rivers, either in a state of suspension or solution. The material in suspension appears to be almost entirely deposited within two hundred miles of the land.

Where great rivers enter the sea, and where we have strong currents, as in the North Atlantic, some of the fine detritus may be carried to a greater distance, but its amount can never be very large. In oceans affected with floating ice we have land debris carried to greater distances than above stated; for instance we can detect such materials in the deposits of the North Atlantic as far south as the 40th parallel N., and in the South Pacific as far north as the 40th parallel S.

Some of the substances in solution, as carbonate of lime and silica, are extracted by animals and plants to form their shells and skeletons; these last, falling to the bottom, form a globigerina, a pteropod, a radiolarian, or a diatom ooze. We have also the bones of mammals and fish mixed up in different kinds of deposits. These, as well as animal and vegetable tissues, generally are a source of phosphates, fluorides, some oxide of iron, and possibly of other inorganic material.

Sir Wyville Thomson, early in the cruise, suggested that much of the inorganic material in deposits is derived from the source to which I have just alluded. Our subsequent observations have, I think, shown that originally Sir Wyville gave too much importance to this as a source of the materials in our deep deposits.

*Second.*—We have the dust of deserts, which is carried great distances by the winds, and which, falling upon the ocean, sinks to the bottom and adds to the depositions taking place. In the trade wind regions of the North Atlantic we have a very red-coloured clay, in deep water, which is largely made up of dust from the Sahara. Such dust frequently falls in this region as what is called blood-rain.

*Third.*—We have the loose volcanic materials, which have been shown to be universally distributed as floating pumice, or as ashes carried by the wind.

This short review shows that the clay in shore deposits is chiefly derived from river and coast detritus. As we pass beyond about one hundred and fifty miles from the shores of a continent the character of the clayey matter changes. It loses its usual blue colour, and becomes reddish or brown, and particles of mica and rounded pieces of quartz give place to pumice, crystals of sanidin, augite, olivine, &c. All this goes, I think, to show that in deposits far from land the clay is chiefly derived from volcanic debris, though in the region of the North Atlantic trade winds much of it may be derived from the feldspar in the dust of the Sahara.

The pumice which floats about on the surface of the sea must be continually weathering, and the clay which results and the crystals which it contains will fall to the bottom, mingling with the deposit which is in course of formation. In our purest globigerina ooze this clay and these crystals are present. If a few of the

shells, say thirty foraminifera, are taken from such a deposit, and carefully washed, and then dissolved away with weak acid, a residue remains which is red-brown or grey in colour, according to the region from which the ooze came. If the same number of shells be collected from the surface and dissolved away in the same manner, no perceptible residue is observed. The clayey matter would therefore seem to have infiltrated into the shells soon after they fell to the bottom.

I have already mentioned several instances of pumice-stones having been found on coral reefs. Many more instances could be given. These stones, undergoing disintegration in these positions, add clay, crystals of augite, hornblende, magnetic iron ore, &c., to the limestones which the coral animals are building up.

I have found these crystals in the limestones and red earth of Bermuda, and in a specimen of the limestone from Jamaica.

This observation, it appears to me, points out that the red earth of Bermuda, Bahamas, Jamaica, and some other limestones, may originally have been largely derived from fragmental volcanic materials, which were carried to the limestone while yet in the course of formation. There are also small particles of the peroxide of manganese in the red earth of Bermuda.

### *Peroxide of Manganese.*

Peroxide of Manganese occurs widely in ocean deposits, either as nodules, incrustations, or as depositions on the bottom itself. It has been found most frequently in the nodular form in the deep-sea clays far from land. It also occurs in the organic oozes, when these contain much volcanic debris, or are near volcanic centres.

In shallow water, near some volcanic islands, it covers shells and pieces of coral or pumice with a light brown incrustation. It has been met with very sparingly, if at all, in shore deposits removed from volcanic centres.

In my preliminary report above referred to, I stated that further investigation might show that manganese nodules and depositions abound in these regions where we have much of the debris of augitic or heavy lavas.

A re-examination of specimens since our return confirms this view. Wherever we have pumice containing much magnetite,

olivine, augite, or hornblende, and these apparently undergoing decomposition and alteration, or where we have evidence of great showers of volcanic ash, there we find the manganese in greatest abundance. This correspondence between the distribution of the manganese and volcanic debris appears to me very significant of the origin of the former. I regard the manganese, as we find it, as one of the secondary products arising from the decomposition of volcanic minerals.

Manganese is as frequent as iron in lavas, being usually associated with it, though in very much smaller amount. In magnetite and in some varieties of augite and hornblende the protoxide of iron is at times partially replaced by that of manganese.

In the manganese of these minerals, and in the carbonic acid and oxygen of ocean waters, we have the requisite conditions for the decomposition of the minerals, the solution of the manganese, and its subsequent deposition as a peroxide.

The carbonic acid converts the silicates of the protoxides of manganese, and the protoxides of manganese into carbonate of manganese, and thus prepares the way for oxidation by the oxygen of the water.

It is probable that the action of the carbonic acid is not apparent, and that the manganese is at once deposited as a high oxide if not as the peroxide. This theory is essentially the same as that which Bischof gives for manganese ores generally. I have laid a series of these manganese depositions on the table. An inspection of these and their localities will show that in the clays and oozes the depositions are nodular in form. If a section be made of one of these, a number of concentric layers will be observed arranged around a central nucleus—the same as in a urinary calculus. When the peroxide of manganese is removed by strong hydrochloric acid, there remains a clayey skeleton which still more strongly resembles a urinary calculus.

This skeleton contains crystals of olivine, quartz, augite, magnetite or any other materials which were contained in the clay from which the nodule was taken. In the process of its deposition around a nucleus, the peroxide of manganese has inclosed and incorporated in the nodule the clay and crystals and other materials in which the nucleus was imbedded. The clayey skeleton thus

varies with the clay or ooze in which it was formed. Those from a fine clay usually adhere well together; those from a globigerina ooze have an areolar appearance; those from a clay with many fine sandy particles usually fall to pieces. Mr Buchanan informs me that the purest portions of these nodules, that is those portions made up of closely packed concentric layers, contain from 30 to 34 per cent. of the peroxide.

Taking the nodule as a whole, it will of course contain very much less than this. The nucleus varies in each nodule, and that part of a nodule which is made up of concentric layers will vary with each locality, and with the depth from which it comes. We may expect therefore that analysis will show considerable variations in the amount of alumina, silica, and metals, lime, &c., in the nodules from different stations. At some places in the Pacific the nodules show periods of deposition very distinctly. We have first a very compact nodule which may have a shark's tooth for a nucleus, and which appears to have been formed slowly. Then there would seem to have been a shower of ashes. After a time manganese was again deposited, inclosing in the nodule a layer of these ashes. The most frequent nucleus in the nodules is a piece of pumice or other volcanic fragment.

In deep-sea clays, far from land, sharks' teeth, ear-bones of whales, and fragments of other bones are very often the nucleus around which the manganese is deposited. In one instance a piece of siliceous sponge forms the nucleus. In a globigerina ooze a portion of the deposit has apparently formed the nucleus. In these we have perfect casts of the foraminifera, but all the carbonate of lime has been removed. The volcanic fragments which have formed the nuclei of nodules appear frequently to have undergone peculiar alterations. For instance, obsidian is usually surrounded by beautiful agate bands.

When we found the bottom composed almost entirely of volcanic ashes, or so hard from other reasons that the sounding tube did not penetrate it, the manganese was deposited in layers over the bottom itself. Large pieces of this nature were taken several times.

The escape of carbonic acid through the floor of the ocean near volcanic islands may in these regions greatly accelerate the processes which end in the deposition of the peroxide of manganese,

and account for the great abundance of it in some such localities where we found it.

*Native Iron and Cosmic Dust.*

While examining the deposits during the cruise I frequently observed among the magnetic particles from our deep-sea clays small round black coloured particles which were attracted by the magnet, and I found it difficult to account for the origin of these.

On our return home I entered into a more careful examination of the magnetic particles. By means of a magnet carefully covered with paper I extracted these particles from the deposits, from the pumice-stones, and from the manganese nodules of many regions. The great majority of these magnetic particles are magnetic iron ore and titaniferous iron, either in the form of crystals, or as fine dust. In the clays, and in the manganese nodules from stations far from land and in deep water, there were again noticed many small, round spheres among the magnetic particles.

On mentioning this to Professor Geikie, he suggested that I should try the method employed by Professor Andrews of Belfast for detecting minute particles of native iron.

This process consists in moistening the magnetic particles, which have been extracted by means of the magnet, with an acid solution of sulphate of copper, when copper is at once deposited on any native particles which may be present. In this way I have detected native iron in many of our deposits, in the powdered portions of manganese nodules, and in pumice-stones.

Professor Andrews tells me that there can be little doubt that the particles on which copper is deposited are native iron, as he has found that it is not deposited on nickel, and the chances of cobalt being present are very slight. Professor Andrews warned me on the extreme precautions necessary in conducting these observations, that no iron from a hammer or other instrument should get at the specimen under observation.

It is true that all specimens of our deposits have been obtained by means of dredges and iron gear, and some of these particles may be from this source.

Many of the particles must have another origin. I have taken two of our manganese nodules, and washing them carefully, taking

care to let no iron instrument come near them, have broken them by rapping them together. Then taking only the interior parts of these nodules I have pulverized them in a porcelain mortar. The magnetic particles were afterwards extracted by a magnet covered with paper. Now, placing these particles on a glass slide under the microscope, and adding the sulphate of copper solution, there was in a few moments a deposit of copper on several small perfect spherules, varying in size from the $\frac{1}{1000}$ to the $\frac{1}{300}$ of an inch in diameter. I have placed some of these spherules under the microscope and now show them to the Society. It will be noticed that on one the copper is not deposited all over the sphere, but in ramified spider-like lines. On the cut surface of a meteorite, from Professor Sir Wyville Thomson's collection, which I also exhibit, the copper is precipitated in precisely the same manner as on the little sphere from the manganese nodule. Besides the spherules on which the copper is deposited, there are others generally of a larger size and dark colour. These are, so far as microscopic examination shows, quite like the particles on the mammillated outer surface of this Cape meteorite, also from Sir Wyville's collection.

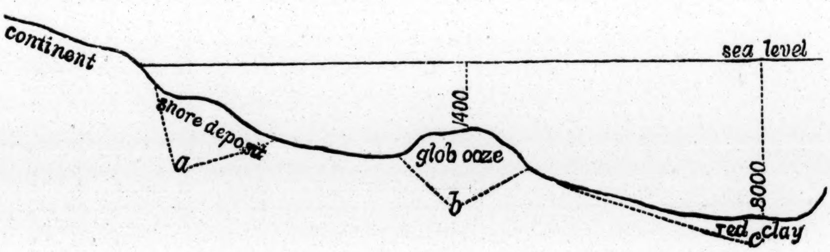
These spherules have hitherto only been noticed in those deposits in deep water far from land, and where for many reasons we believe the rate of formation of deposits to be very slow.

They occur also only in those manganese nodules which come from the same deep-sea clays or deposits far from land.

The particles of native iron found in pumice-stones are not numerous, and never take the form of spherules so far as observed. Some of these particles of native iron may then come from the dredge. Other particles come from the pumice and the volcanic materials. Professor Andrews long since showed that minute particles of native iron existed in basalt and other rocks. And lastly the spherules of which I have been speaking appear to have a cosmic origin.

The reason, for these spherules occurring only in deposits far from land and in deep water, may be more apparent by reference to the annexed diagram, which might represent a section from the west coast of South America out into the Pacific 500 miles. Along the shores of the continent as at *a* we have an accumulation of river and coast detritus. At *b* in depths from 1400

to 2200 fathoms we have a globigerina ooze mostly made up of surface shells. At *c*, in a depth of 2300 to 3000 fathoms, all the surface shells are removed from the bottom. No coast detritus reaches this area, and we find in the deposit pumice stones, some volcanic ashes, manganese nodules, sharks' teeth, and ear bones of whales. It is only in areas like this that we find sharks' teeth and ear bones of cetaceans in any numbers. Some of them from the same haul are deeply surrounded with manganese deposit, and contain little animal matter ; while others have no deposit on them, and seem quite recent. These, and other facts which might be mentioned, all argue for an exceedingly slow rate of deposition. Now it is in these same areas that the spherules of native iron and other magnetic spherules are found, both in the deposits and in the manganese nodules from them.




Finding them in this situation favours the idea that they are of cosmic origin, for in such places they are least likely to be covered up or washed away. It is certainly difficult to understand why the spherules on which the copper is precipitated have not become oxidised. If nickel be present in them, this may retard oxidation to some extent.

The manganese depositions in our ocean deposits are very different in structure and composition from any of the ores of manganese I have had an opportunity of examining, and the deposits of the deep sea far from land have not, so far as I know, any equivalents in the geological series of rocks.

All the subjects treated of in this paper are still under investigation, and at some future time I hope to present a much more detailed account.

These observations seem to me to give ground for the following conclusions:—

*First*, That volcanic debris, either in the form of pumice stones, ashes, or ejected fragments, are universally distributed in ocean deposits.

*Second*, That pumice stones are continually being carried into the sea by rivers and rains, and are constantly floating on the surface of the ocean far from land.

*Third*, That the clayey matter in deposits far from land is principally derived from the decomposition of the feldspar in fragmental volcanic rocks, though in the trade wind region of the North Atlantic the dust of the Sahara contributes much material for clay.

*Fourth*, That the red earth of Bermuda, Bahamas, Jamaica, and other limestone countries, is most probably originally derived from the decomposition of pumice stone, while these limestones were in the process of formation.

*Fifth*, That the peroxide of manganese is probably a secondary product of the decomposition of the volcanic rocks and minerals present in the areas where the nodules of manganese are found.

*Sixth*, That there are many minute particles of native iron in deposits far from land; that some of these particles are little spherules; that these last, as well as some other spherules which are magnetic, have probably a cosmic origin.

*Seventh*, That the peroxide of manganese depositions in the deep sea are different in structure and composition from known ores of manganese.

*Eighth*.—That we do not appear to have equivalents of the rocks, now forming in the deep sea far from land, in the geological series.

In conclusion, I have to acknowledge much assistance in these investigations from all my colleagues, especially my indebtedness to Sir Wyville Thomson and Mr Buchanan.

Since my return I have received many hints from Professors Tait, Geikie, Turner, Dr Purves, Mr Morrison, and other gentlemen.

In much of the mechanical work which an examination of these deposits has entailed, I have, both during the cruise and since my return, had the assistance of Frederick Pearcey.

## 4. On New and Little-known Fossil Fishes from the Edinburgh District, No. I. By R. H. Traquair, M.D., F.G.S.

### FAMILY PALÆONISCIDÆ.

GENUS *Nematoptychius*, Traquair, 1875.

This genus was instituted by the author for the reception of the *Pygopterus Greenockii* of Agassiz, and characterised in the "Annals and Magazine of Natural History" for April 1875. It differs from *Pygopterus* in the form of the scales of the flank, which are much higher than broad, and having their articular spine arising from the whole, or nearly the whole of the upper margin; in the structure of the pectoral fin, in which all the rays are articulated for the greater part of their extent; and in the form of the anal, which is in shape like the dorsal, and is not produced backwards in the peculiar fringe-like manner characteristic of *Pygopterus*.

Since the publication of the notice above referred to, remains of *N. Greenockii* have turned up in two other localities near Edinburgh, viz., near Juniper Green in the horizon of the Wardie Shales (Museum of Science and Art), and at Raw Camps, near Mid Calder, in that of the Burdiehouse Limestone (Collection of the Geological Survey of Scotland).

The following is new to science.

*Nematoptychius gracilis*, sp. nov. Traquair.

Of this two specimens have occurred at Gilmerton. The more perfect of these, compressed on its side, displays the entire contour of the fish, including all the fins, and measures 9 inches in total length, by $1\frac{1}{8}$ inch in depth between the head and the ventrals; the length of the head is contained about $4\frac{1}{2}$ times in the total. The ventral fins arise opposite a point $3\frac{1}{2}$ inches distant from the tip of the snout; the commencement of the anal is midway between that of the ventral and of the caudal; the dorsal is situated nearly opposite the anal, commencing only $\frac{1}{4}$ inch in front of it. The form of the fish is thus elongated and slender, gradually tapering from behind the shoulder towards the tail, the dorsal fin being situated very far back. The other and slightly longer spe-

cimen lies compressed on its back, and shows the under surface of the head, both pectoral and both ventral fins, with traces also of the dorsal, anal, and caudal. Its length is $9\frac{1}{2}$ inches, but the fish must originally have been a little longer, as its caudal extremity is imperfect.

The scales are very small, and much disarranged, as is the case in nearly all the fishes occurring in the same bed, but their configuration is apparently the same as in *N. Greenockii*, and their external ornamentation consists, as in that species, of very fine oblique, thread-like, branching, and anastomising ridges; the median ridge-scales, extending from behind the dorsal fin along the upper margin of the caudal body-prolongation, are very large and pronounced. The bones of the head are much crushed and broken, so that only a few of them can be made out. The suspensorium is very oblique and the gape extensive, the length of the lower jaw being, in the first mentioned specimen, $1\frac{1}{2}$ inch. The external surface of the lower jaw is ornamented with a minute and very close tuberculation; the dental margin of the maxilla is also tuberculated, but the rest of its surface is marked with delicate ridges, which run for the most part parallel with its superior and posterior margins. Large conical teeth occur in both jaws, with a few of the external series of smaller ones. One of the larger teeth in the mandible of specimen No. 2 measures a little over $\frac{1}{8}$ inch in length by $\frac{1}{16}$ in diameter at the base; its form is regularly and acutely conical, with well-marked smooth enamel-cap at the apex, below which the surface is delicately and beautifully striated, the striæ being more pronounced than is usually the case in *N. Greenockii*. The opercular bones are not visible, but some of the branchiostegal rays may be detected; their outer surfaces are ornamented by very fine flexuous ridges. The paired fins are moderate in size; indeed they might safely be termed small. The pectoral of No. 1 measures one inch in length; in neither specimen can its number of rays be ascertained, but it is evident that the principal ones were unarticulated for about $\frac{1}{3}$ of their length. The length of the ventral in the first specimen is $\frac{3}{4}$ inch; its rays, probably 25 in number, are delicate, smooth, and with their transverse articulations rather far apart. The dorsal and anal fins resemble each other in form, but the latter is apparently slightly the larger; both are triangular, acuminate,

high in front, with concavely cut out posterior margin; the height of the dorsal in front is $1\frac{1}{3}$ inch, its base of origin is disturbed; the apex of the anal is imperfect, its base measures $\frac{7}{8}$ inch. Their rays are numerous, slender, and smooth, dichotomising only near their extremities, and having their transverse articulations comparatively distant. The caudal, as it lies before us, can hardly be called inequilobate, but as the upper lobe appears somewhat crumpled, its entire length is probably not accurately exhibited. It is deeply bifurcated, the lower lobe being narrow and of great length, measuring $1\frac{3}{4}$ inch, though its extreme point is cut off; its rays are like those of the dorsal and anal, being slender, smooth, and with rather distant articulations, the joints being at first more than twice as broad, but getting a little closer towards the end of the rays; in the upper lobe the rays are, as usual, short and very delicate. Small and closely set fulcra are observable on the anterior margin of all the fins.

*Remarks.*—It is of course at once evident that the present species is closely allied to the powerful *Nematoptychius Greenockii*, Ag. sp., of the Wardie Shales; it differs, however, from the latter in several particulars beside its smaller size. The transverse articulations of all the fin-rays are considerably more distant; and the principal rays of the pectoral are unarticulated for a greater distance than is the case in *N. Greenockii.* The form of the laniary teeth differs also somewhat in the two species. In *N. gracilis* these are more regularly conical, gradually tapering from the base to the apex; whereas in *N. Greenockii* they assume a more slender form, owing to the more sudden narrowing of the base upwards into the body of the tooth, although the relative proportion of the diameter of the base to the length of the tooth is about the same. The specific name "gracilis" is bestowed on the present species in allusion to the slender and elegant shape of the body.

*Geological Position and Locality.*—The two specimens above described were found in the blackband ironstone at present wrought in Venturefair Colliery, Gilmerton, near Edinburgh, and are both preserved in the Museum of Science and Art, Edinburgh. This ironstone, well known for its *Rhizodus* remains, is a member of the Lower Limestone group of the Carboniferous Limestone series of the Lothians, and occurs along with the North Greens coal-seam,

the lowest wrought coal in the Edinburgh district, between the first and second Marine Limestone beds in ascending order.

*Gonatodus*, gen. nov., Traquair.
*Amblypterus*, Agassiz (pars.).

The body is fusiform, the scales rather large, rhomboidal, ornamented with striæ and punctures, sometimes nearly perfectly smooth. Rays of pectoral fin articulated; base of ventrals short; dorsal and anal large, triangular, dorsal situated behind the middle of the back so that the middle of its base is opposite the commencement of the anal; caudal following closely on the anal, powerful and deeply cleft with well developed body-prolongation along the upper lobe; rays in all the fins numerous, and closely jointed. Suspensorium not quite so oblique as in *Palæoniscus*, *Elonichthys*, and most other genera of the family, but more so than in *Amblypterus;* operculum large, oblong, suboperculum wanting, interoperculum * quadrate; branchiostegal rays numerous, with a median lozenge-shaped plate behind the symphysis of the mandible. Jaws stout; teeth closely set and of very peculiar form, being cylindro-conical, first inclined slightly inwards, then bent outwards at an obtuse angle, the apex coming then by another curvature to point upwards (or downwards in the case of the upper jaw).

*Gonatodus punctatus*, Agass. sp.

*Amblypterus punctatus* (pars.) Agassiz, Poissons Fossiles, vol. ii. pt. 2, p. 109; Atlas, vol. ii. tab. 4 c, fig. 4, but *not* figs. 3, 5, 6, 7, 8.
(?) ———— *anconoæchmodus*, Walker, Trans. Geol. Soc. Edin., vol. ii. pt. 1 (1872), pp. 119–124.

The length of the entire specimens varies from 5½ to 7¼ inches, but in none is the extreme point of the upper lobe of the tail preserved. The length of the head is contained about four times, the greatest depth of the body about three times in the total length up to the bifurcation of the caudal fin. The head is short, with bluntly

* The bony plate which I here denominate "interoperculum" is the same as that which, in the Palæoniscidæ, has hitherto been considered as "suboperculum." In *Rhabdolepis* there occurs between it and the operculum another and smaller plate, which I interpret as "suboperculum," and which is wanting in most of the genera of this family. (See the author's account of the structure of the Palæoniscidæ in the Memoirs of the Palæontographical Society for 1877).

rounded snout; the external ornament of the bones of the cranium proper is rugose in character. The operculum is oblong, broader above than below, and ornamented with delicate ridges which radiate from the anterior-superior angle downwards and backwards over its surface; the interoperculum is nearly square, and marked with ridges which for the most part pass horizontally over its surface from before backwards; the præoperculum is well developed. The jaws are stout; the broad part of the maxilla is ornamented with delicate and not very closely placed branching and anastomosing ridges, which for the most part tend to run parallel with its superior and posterior borders; the striation of the mandible is close, the ridges running longitudinally, but the dentary margin is finely tuberculated. The teeth with which the jaws are armed are most peculiar in form and arrangement; they are about $\frac{1}{24}$ to $\frac{1}{20}$ inch in length, slender-cylindrical in shape, but suddenly narrowed near the extremity to a sharply conical apex. Each tooth is first inclined a little inwards, then bent outwards at an obtuse angle, and again bent so that the apex comes to point upwards (or downwards in the case of the maxillary teeth). They are nearly uniform, and arranged in one closely set row, inside which there are no larger teeth, nor have I seen any evidence of smaller ones outside. The branchiostegal rays are thirteen on each side, the anterior of each series being broader than those behind, besides which there is a median lozenge-shaped plate in front. The bones of the shoulder girdle are well shown in most of the specimens, and like those of the face are ornamented externally with flexuous branching and anastomosing ridges.

The scales of the flank are slightly higher than broad, with gently concave upper, and convex lower margin; the articular spine is well marked. On the under surface, the socket for the spine of the scale below is distinct, but the keel is obsolete; the latter appears as we proceed backwards towards the tail, while the spine and its socket diminish and ultimately disappears. The posterior margin of the scale is finely and obliquely serrated. On the outer surface the margin overlapped by the scale next in front is very narrow; the exposed area is in the most anteriorly situated scales, is ornamented with delicate and rather feebly marked ridges, best marked along the anterior and inferior margins with which

they run parallel, and usually becoming speedily obsolete over the rest of the scale, so as to leave a considerable space above and behind, marked only with tolerable coarse punctures, though in many cases shallow grooves also extend for some distance forwards from the notches between the denticulations of the posterior border. These striæ are much more pronounced in some specimens than in others; except on the small scales at the base of the dorsal fin, where they are pretty well marked, they cease to be observable before the origin of the ventrals, whence backwards the only scale-ornament consists of scattered punctures passing into short oblique furrows, especially near the interior margin, these punctures and furrows being persistent even on the small lozenge-shaped scales clothing the sides of the caudal body-prolongation. The scales also vary considerably in size on different parts of the body, becoming rapidly smaller posteriorly. One from the middle of the flank between the head and ventral fins in a specimen of 6 inches, measures nearly $\frac{1}{5}$ inch in height by $\frac{3}{20}$ in breadth, while the breadth of one from the side of the posterior part of the body opposite the termination of the dorsal fin is only equal to one-half that of the former. The scales immediately below and adjoining the base of origin of the dorsal fin are of particularly small size. The usual large scales are seen in front of the dorsal and anal fins, and the squamation of the prolongation of the body axis along the upper lobe of the caudal present nothing specially worthy of note.

The pectoral fins are acutely pointed, and of considerable expanse. The length of each is equal to about three-quarters that of the head; the ventrals are smaller; the base of each is rather short. They are likewise pointed in shape, and have their posterior margins considerably cut out. The dorsal is placed behind the middle of the back, so that the centre of its base is nearly opposite the commencement of the anal; both these fins are large and triangular; the caudal is powerful and deeply cleft. The rays of all the fins are very numerous and delicate; in the pectoral these cannot be less than 30; in the ventral, 23; in the dorsal and anal, 45 each; those of the caudal cannot be counted. The articulations of the fin rays are also tolerably close, especially in the finer rays of the posterior part of each fin, where the joints appear nearly square, being in the other rays rather longer than broad; the arti-

culations are more than usually distant towards the proximal extremities of the principal rays of the pectoral, and also, though to a less extent, in the lower lobe of the caudal. The joints are scale-like in general aspect; the distal margin of each is notched or concave, the proximal correspondingly convex; and the outer surface is in most cases marked with at least one delicate furrow parallel with the anterior and posterior borders; near the bases of the dorsal and anal fins the joints present indeed an appearance as of fine striation. The fulcra of the anterior margins of the fins are closely set and very minute, being only observable with the aid of a lens.

*Remarks.*—Under the name of *Amblypterus punctatus*, three imperfect specimens of fossil fish from the shales of Wardie were described and figured by Agassiz in the "Poissons Fossiles." One of these is a head with the anterior part of the body (Atlas, vol. ii. tab. 4 B, fig. 4); the second (*ib.* fig. 5) wants the head and shoulders and the extremity of the tail; the third (*ib.* fig. 3) displays the entire caudal fin, but is obliquely cut off just in front of the dorsal and anal. The principal characters which he assigned to this species were—the considerable depth of the anterior part of the body; the character of the teeth, which had the form of small obtuse cones apparently disposed in several rows; and the ornament of the scales, which consisted, in those in front, of oblique undulating lines closer together at the anterior part of each scale and mingled with punctures, the latter more numerous towards the posterior margin; while on the scales of the hinder part of the body those lines were less crowded, and the punctures more numerous, the former entirely disappearing on the scales of the pedicle of the tail, where only a few scattered points were left.

For some time after commencing the study of the fossil fishes of Wardie, this species "*punctatus*," stated by Agassiz to be common in that locality, was to me a complete enigma, as among the numerous *entire* specimens of fish which I had the opportunity of examining, I could not find one which agreed in all its characters with Agassiz's description, though in some the *anterior*, and in others the *posterior* part of the fish answered well enough. The mystery was, however, at once cleared up by an examination of the figured specimens, of which two, collected by Lord Greenock,

are in the collection of the Royal Society of Edinburgh; while the third, collected by Dr Buckland, and contained in the Oxford University Museum, was forwarded to me with great liberality by Professor Prestwich. A comparison of these specimens with a series of entire fishes from the Wardie beds establishes the fact, that the *Amblypterus punctatus* of Agassiz was founded upon fragments of two distinct species, the specimen with the head, but without the hinder part of the body, being even generically distinct from the other two, which display the hinder part, but without the head,—the fishes to which they respectively appertain differing not only in dentition, but also in many other particulars connected with the head, the scales, and the fins.

The peculiar form and arrangement of the teeth in the first of these render necessary the institution of a new genus, to which I have given the name *Gonatodus*.* These teeth were somewhat incorrectly described by Agassiz as being "en cones obtus," this appearance in the specimen he examined being due to their being there only seen in antero-posterior vertical section, their peculiar flexures and pointed apices being invisible; their being disposed "sur plusieurs rangées" seems also to be an error as far as the mandibles and maxilla are concerned, though probably there were additional teeth on the margin of the palate. Perfect examples of the species to which the other two type specimens belong show that the teeth are in it acutely conical, incurved, and of different sizes, large and small, and that in these and other respects the fish is closely allied to the *Amblypterus nemopterus*, *Palæoniscus striolatus*, and *P. Robisoni* of Agassiz, along with which forms it is, in my opinion, referable to the genus *Elonichthys* of Giebel.† It now, however, becomes a question for which of these two fishes the specific term "*punctatus*" should be retained. Now, although the enlarged representations of scales given by Agassiz (Pois. Foss. Atlas, vol. ii. tab. 4 c. figs. 6 and 7) are taken from the second species (*Elonichthys*), yet the term is indeed applicable to both, and as the characters of the head and teeth are

* γονυ, *knee;* and οδους, *tooth.*

† The reasons for removing these forms from the genera *Amblypterus* and *Palæoniscus*, and uniting them with *Elonichthys*, will be given in my next communication.

those which more especially distinguished Agassiz's conception of "*Amblypterus punctatus*" from his *A. nemopterus* with which he contrasted it as occurring in the same beds, it seemed to me more appropriate to retain his name "*punctatus*" for the species of which these peculiarities are characteristic. For the other I propose the name *Elonichthys intermedius;* it is very closely allied both to *E. nemopterus* and *E. striolatus*, and will be described in my next communication on the fossil fishes of the Edinburgh district.

The peculiar dentition of *Gonatodus* was, however, first correctly described by Mr R. Walker* in a fish from the oil shales of Pitcorthie, Fifeshire, to which he gave the name of *Amblypterus anconoæchmodus*, the horizon in which it occurred being probably that of the Burdiehouse Limestone. Mr Walker's fish undoubtedly belongs to the same genus with that described above, and may possibly be the same with *G. punctatus*—if not, it is certainly very closely allied, —but I have had no opportunity of instituting a comparison by means of actual specimens. Mr Walker, however, makes no mention of punctures as a scale ornament, and his figures represent the entire surface of the scale covered—as he says in the text—"with fine striæ which run parallel with the anterior and lower margins," and "are more conspicuous on the scales of some specimens than on those of others." † Regarding the arrangement of the teeth in the lower jaw, Mr Walker also states that they "are placed alternately one close to the outside margin, the next to it is fully half its own thickness farther in, and so on the whole length of the bone,"—an appearance of which I have observed some slight indications in *G. punctatus*, but not with the regularity described.

*Geological Position and Locality.*—The specimens from which the above description of *Gonatodus punctatus* has been drawn up are in the Museum of the Royal Society of Edinburgh and in the private collection of the author. They are all preserved in nodules of clay

* "On a New Species of *Amblypterus* and other fossil fish remains from Pitcorthie, Fife." Trans. Edin. Geol. Soc. vol. ii. pt. 1 (1872), pp. 119–124.

† In the Wardie specimens the scales appear for the most part dull, and delicately striated all over; this is, however, *internal structure*, not external sculpture, and is due to the flaking off of the external ganoine layer. When this is preserved *in situ*, as it is here and there in many specimens, the surface of the scale is brilliant, largely punctured, and the appearance of striation more or less limited or obsolete, as already described.

ironstone, from the lower Carboniferous shales of Wardie, near Edinburgh, belonging to the Cement-stone group of the Calciferous sandstone series.

The next species is new, and from a higher horizon.

*Gonatodus macrolepis* sp., nov. Traquair.

*Description.*—The usual length of examples of this species is from four to six or seven inches, but although a considerable number of specimens more or less perfect have occurred in no two do the proportional measurement agree, owing to the greater or less amount of alteration of form, frequently amounting to positive distortion, which they have undergone, apparently both soon after death, and also during the consolidation of their ironstone matrix. Seldom do the scales, save on the caudal body-prolongation, remain in their original relations to each other on any considerable part of the body, but are always more or less jumbled up, even though the contour of the fish may remain tolerably regular, and the shape and structure of more or fewer of the fins be quite intact. As remarked in the description of *Nematoptychius gracilis*, this condition affects nearly all the small fishes occurring in the Gilmerton ironstone. In one example of the present species in my collection, the apex of the anal fin appears neatly cut off, and dislocated a quarter of an inch forward from the rest of the fin.

The most perfect specimen in my collection is 6½ inches in length by 1¾ in depth at the ventral fins, and is nearly perfect. In no specimens are the bones of the head well shown, these being always more or less crushed and broken; what can be seen of them shows that they were conformed essentially as in the preceding species, and sculptured much in the same way, though perhaps a little more coarsely. The configuration of the teeth is also essentially the same, though they appear to be a little more clumsy in shape, and not quite so regular in arrangement. But the most salient peculiarity of the present species lies in its scales, which are considerably larger than in *G. punctatus*, except on the caudal body-prolongation, where they are equally small. Their outer and brilliantly-polished surfaces are also devoid of ornament, and might indeed be described as completely smooth, only a few delicate punctures being discernible by careful examination with the lens;

their posterior margins are finely denticulated as in the preceding species. The form and position of the fins is the same as in *G. punctatus*, but their rays are slightly coarser and proportionally fewer in number, though it is difficult to ascertain with accuracy their numbers in the various fins. The articulations of the rays are also a little closer, but the configuration of the joints is the same, these being emarginate distally, convex proximally, and with a little furrow parallel with their anterior and posterior margins, but I have not observed any additional furrows or striæ than those near the bases of the dorsal and anal as in the Wardie species.

*Geological Position and Locality.*—A considerable number of examples of this species have occurred in the Blackband ironstone at Venturefair Colliery, Gilmerton, and are contained in the Edinburgh Museum of Science and Art, and in the private collection of the author. A fragment in the Hunterian Museum of the University of Glasgow, from the ironstone of Possil, also a member of the Carboniferous Limestone series, though higher in position than that of Gilmerton, is probably also referable to the same.

### 5. On the Ruff (*Machetes pugnax*). By Professor Duns.

The exceedingly beautiful bird now on the table was forwarded to me on the 1st of September last by Mr Wilson, Edington Mains, Chirnside, Berwickshire. It had been shot two days previously. Mr Wilson says, "On comparing it with all the Waders figured by Bewick (the only work of the kind which I possess), I find none that correspond; whence I infer that it is really a *rara avis.*" He adds, "When noticed by the edge of the pond by my children it had a young one with it, which they saw it feeding. The young one, they said, was much lighter in its plumage, but was old enough to fly strongly." The note led me to expect a full-grown female wader and young one. But the size of the bird and its general features of maturity showed it to be a male, in full winter plumage. Its companion, described as young, doubtless from its size, seems to have been the female, or reeve, which is little more than half the size of the male. In this respect the ruff differs from most of the sub-family *Tringinæ*, in which the females are generally larger than the males.

The ruff is polygamous. After the breeding season a separation takes place between the sexes, which continues till the approach of the following spring. The example now before us is thus exceptional, as occurring along with one female long after the breeding season was past, which is late in the spring, or in May. At one time these birds were met with in great numbers in the low-lying districts of Norfolk and Lincoln, where they bred. Even in these localities they are now seldom met with. There are no instances on record of their nesting in Scotland, where they are even more rare than in England. "On the east coast of Scotland," says Macgillivray, "they usually appear about the middle of September and depart in about a fortnight; but I have never seen an adult male killed there, the little flocks that occur being young birds and females." "Except in a very few instances," says Mr Gray, "I have never met with the ruff in the western counties. One or two occasionally penetrate as far as the Clyde, but these are mere stragglers."* The forms now noticed appeared at a considerable distance from the coast, in a district, however, which at one time must have presented as good nesting ground as could be found in Norfolk or Lincoln, but which by drainage and many other features of high farming has become almost free from conditions suitable to their habits. It would almost seem as if some birds have a transmitted instinct towards certain localities, which at long intervals finds high expression in certain pairs. Might not this account for the occasional occurrence of the bittern, the night heron, and many other forms in districts where they are now regarded as stragglers? I know, moreover, one locality where the names of places show how common the raven had been at one time, but where only one pair is known to have appeared in forty years. Many instances of this kind might be given. The habits of the ruff have been, I might almost say, so exhaustively described by Montague, Rennie, Selby, and others, as to make it unnecessary to refer to them here. I have, however, placed on the table other specimens than that now noticed, with

* Dr John Alexander Smith has noticed specimens from Carnwath, Alloa, Portobello, and Fenton Barns, East Lothian. As many as a dozen were recently seen near Grangemouth by Mr Harvie Brown, five of which were shot.

the view of indicating the relative size of male and female, of pointing out the profuse and almost grotesque ornamentation of the males at the breeding season, and of showing the wide variation in the plumage of male birds especially. During the breeding season numerous papillæ, or fleshy tubercules, appear on the face, a couple of ear tufts slope gracefully to the hind head, and a large frill or ruff of elongated feathers surrounds the neck. These features continue till about the middle of June, when the birds moult. They then put on the autumn and winter garb. It is next to impossible to find two males ornamented alike. But it is known that the colouring of the frill first assumed is retained through all the changes of plumage that follow in after years. If red originally, it will have that colour as successive breeding times come round. If black, or white, these colours reappear in their season. The fact is curious and interesting from the physiological point of view. The theory of sexual selection does not help to explain it. The birds are polygamous, and the male has to fight to obtain the female. It is not, however, the size or colour of the frill, but the strength of beak and of leg that conquers. Then what is it that determines the colour of the frill in different birds of the same species, and what keeps the hue persistent throughout all the yearly changes of plumage? The questions are easily put. One would like if they were as easily answered.